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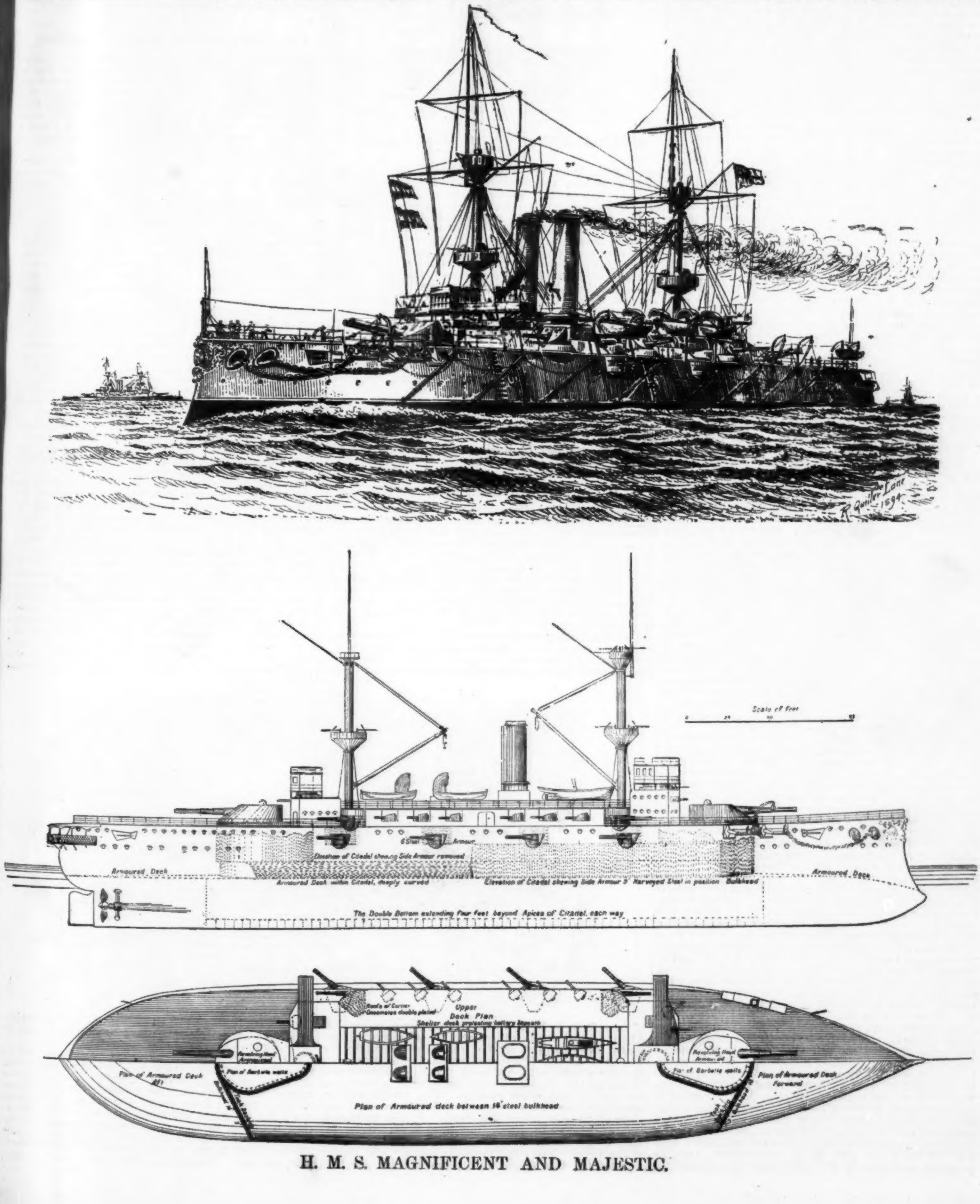
H. M. S. MAGNIFICENT AND MAJESTIC.

WITHIN two months' space of time the finest pair of battle ships that the world has ever produced will have been launched at Chatham and Portsmouth respectively. The Magnificent was successfully floated out of dock upon the 19th of December last, and the Majestic went through the same ceremony upon the 31st of January.

These two vessels, of which a detailed engraving is published in our columns this week, form part of a fleet of seven of precisely similar character already under construction or laid down. When completed they will be, in point of weight of broadside and end-on fire, as well as in respect of armored protection, the most modern and formidable engines of war hitherto seen afloat. For, although the main armament in the barbettes consists of 12 in. 50 ton guns, instead of the



H. M. S. MAGNIFICENT AND MAJESTIC.

huge 70 ton weapons of the Royal Sovereign and Hood, the extra rapidity with which these lighter and more manageable pieces of ordnance can be worked, and the tremendous preponderance of large caliber quick firers which can be discharged six and seven times per minute, render the weight of metal thrown in a given interval of time far greater in the two vessels now under consideration. Similarly, although the actual thickness of armor plating upon the sides and barbettes has been lessened, its capacity for resistance has been increased fifty per cent. by Harveyizing it, and the extent of armored surface has been enormously developed. The superficial armored area of the Magnificent's great citadel is, independently of the barbettes, nearly 9,000 ft.

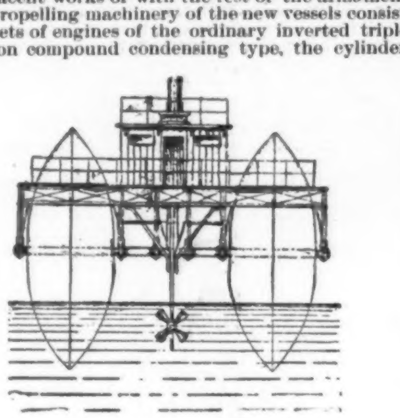
The principal dimensions, etc., of the two new battle ships are as follows: Length, between perpendiculars, 390 ft., or 415 ft. over all; beam, 75 ft. at the water line; mean draught of water, 27½ ft.; displacement, 14,900 tons; indicated horse power, 12,000; speed, under natural draught, 16½ knots, under moderate forced draught, 17½ knots; of coal capacity there is a total storage of 1,800 tons, but only 900 tons of this can be carried at the designed draught.

The disposition of the armored protection is quite different to that of the Royal Sovereign class. Instead of a narrow strip of thick armor at the water line, surmounted by another strip of very thin armor, the upper edge of which is 9½ ft. above the water line, there is a broad streak of Harveyed steel 15½ ft. wide, stretching from apex to apex of a pointed citadel, as will be seen in our engraving. This is 9 in. thick upon the broadsides, and 14 in. thick around the barbettes, where it merges into bulkheads. Within this armored citadel is the thickest portion of the armored deck, where it is 3 in. on the flat and 4 in. upon the curved sloping edges. Forward and aft, beyond the armored bulkheads, the armored deck is 2½ in. thick at its stoutest part. But it will be observed in the engraving that an important modification has been made in the armored deck. In all earlier battle ships the outer edge of this deck is at the summit of the thick armor belt. In the Magnificent and Majestic, however, it curves downward behind the vertical armor, and the lower edges of the two harmonize, as well as the outer edges of the forward and after armored decks, thus bringing the whole to a uniform level of about 5 ft. or 6 ft. below the water line. The protective deck is, therefore, of a truly turtle back character, as first of all developed so prominently in the design of the Vulcan. The barbettes are built upon the citadel ends of the armored deck, and are to be plated with 14 in. Harveyed steel. Upon their summits will be revolving armored hoods of sufficient capacity to hold the gun detachments working the guns by manual power, and as the barbettes are pear shaped in plan, which can be seen from the engraving, there will be room within the thin ends for the ordinary ammunition hoists and ramming gear required for fixed loading positions. There is, however, an axial ammunition trunk within the barbettes, which descends to the magazines direct, to which we shall advert presently. Another feature for the protection of the water line is the filling in with watertight divisions of the angular space between the curved edges of the armored deck and the lower streak of armor belting, thus forming a sort of cofferdam around the vessel at this level. A similar contrivance has been designed for some of the war vessels of France now under construction.

The secondary armament, consisting of 6 in. quick firers, is all protected by 6 in. armor on the outside of the casemates, and 2 in. plates on their other side. A valuable modification has been made in the arrangement of the upper deck battery. Instead of an open space, liable to be swept by the machine and quick-firing guns of the enemy, both from the armored tops and otherwise, this is now inclosed and decked over with a steel shelter deck, the four armored casemates at either corner acting moreover as screens to prevent a raking fire from either quarter. There is also beneath the forward bridge a flying deck, upon which light quick-firing guns will be placed. Above this towers the chart room, rising to an altitude of 75 ft. from the under side of the keel. It is impossible to conceive anything more important to the steadiness and discipline of the guns' crews than the fact of their being able to fight their weapons behind adequate shelter, and this question has been thoroughly solved in the upper works of the Magnificent and Majestic.

The armament of these vessels and its disposition is as follows: Two 12 in. wire 50 ton guns are to be mounted upon each barbette, protected by a steel revolving hood, as in the case of the Barfleur and Renown. Beneath the turntables will be a revolving shell chamber, with an ammunition trunk in the center and hoists, so that loading can be carried out with the guns at any position of training. This is independent of the fixed loading positions, whose hoists are in the pear shaped ends of the barbettes. Thus the rapidity of fire and of the serving of the ammunition are accentuated considerably by this two-fold arrangement, not to speak of the value of an alternative system in the event of one having been placed hors de combat by accident. It will be observed that while the freeboard of the new vessels has been raised to a height of more than 20 ft. forward, the axis of the heavy guns has been also raised to 27 ft. above the water line, being 4 ft. higher than in the case of the Royal Sovereign class. This will admit of the guns being fired axially forward or aft, without endangering the safety of the deck, an impossibility in the earlier vessels. Upon the main deck are eight 6 in. quick firers in armored casemates, four on either broadside, and four more of these guns are upon the upper deck battery, one in an armored casemate at each corner, as will be seen in the engraving. The part of the shelter deck above these last mentioned corner casemates is double plated to give additional strength. In the upper deck battery will be also twelve 12-pounder quick firers upon shielded mountings, six on either broadside, and the remaining four 12-pounders will be forward and aft upon the superstructure. The two forward ones will be under the flying deck. Twelve 3-pounder quick firers will be disposed upon the superstructure, tops, and in other situations. Eight machine guns will also be carried, and five torpedo tubes or dischargers. A glance at the engraving will show that two 12 in. guns, two 6 in. quick firers, two 12-pounder, and seven or five 3-pounder quick firers can be directed simultaneously either ahead or astern, while the broadside fired on either beam would be delivered from four 12 in., six 6 in. quick firers, eight 12-pounder, and eight 3-pounder quick firers. In four minutes a weight of 30,000 lb. of metal would thus be discharged from one broadside, while the corresponding figures forward or aft would be about 12,000 lb. It must be borne in mind that all this concentration of fire has not been obtained, as in the case of the French battle ships of the Charlemagne class, by fitting the guns into lateral grooves like the blades of a pocket knife, which must inevitably sacrifice the stability of the ship when axial fire is employed, but that each gun has a clear arc for itself without interfering with any adjacent works or with the rest of the armament.

The propelling machinery of the new vessels consists of two sets of engines of the ordinary inverted triple-expansion compound condensing type, the cylinders



SECTIONAL VIEW OF M. BAZIN'S BOAT.

being 40 in., 59 in., and 88 in. in diameter respectively, by 51 in. stroke. The twin propellers are of gun metal, and are 17 ft. in diameter, and of 19 ft. 9 in. pitch. The boilers are eight in number, and are of the ordinary marine type, being 16 ft. 1 in. in diameter and 9 ft. 3 in. long, each containing four furnaces. They weigh about 50 tons each. The working pressure will be 150 lb. per square inch. The main steam pipes will be of steel. The chief novelty in this connection is the application of induced instead of forced draught. The makers of the Magnificent's engines are Messrs. John Penn & Sons; those of the Majestic will be made at Barrow.

The two new battle ships, although very fine in their lines forward and aft, are tolerably square at the midship section, the result being that their coefficient of fineness below the water line area is 0·65 of a solid rectangle contained by the length, beam, and draught.

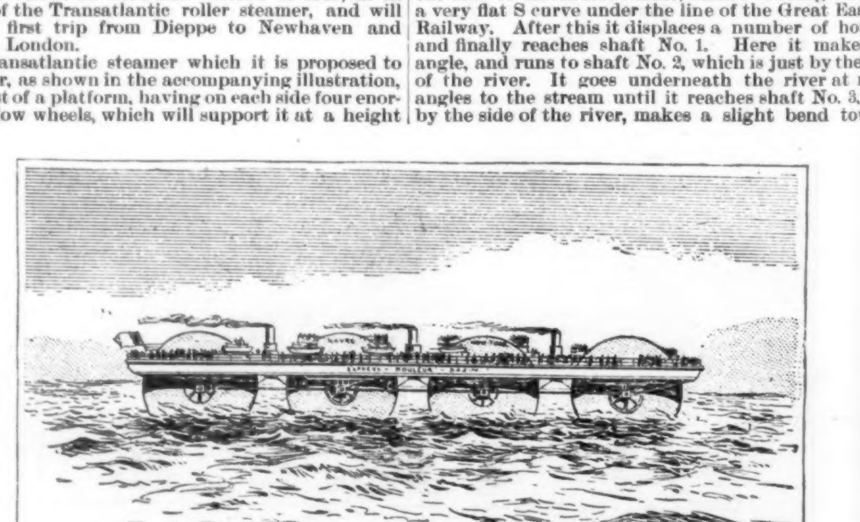
The Magnificent was only laid down upon the 18th of December, 1893, and the Majestic upon the 5th of February last, hence their readiness for floating out in so short a space of time is almost phenomenal.

The upper engraving on first page shows the ships as they will probably appear at sea; but, of course, small changes may be made in the arrangement of boats or ventilators.—The Engineer, London.

M. BAZIN'S ROLLER STEAMSHIP.

THE old idea of a roller steam vessel has been revived by M. Bazin, a French engineer. M. Bazin recently explained his plan to a number of naval officers, engineers and scientists by means of a model roller steamer, and informed his hearers that a trial steamer is to be built at St. Denis for channel service only. This boat will be 131 ft. in length and 39 ft. in breadth, having only three wheels on each side instead of four, as in the case of the Transatlantic roller steamer, and will make its first trip from Dieppe to Newhaven and thence to London.

The Transatlantic steamer which it is proposed to build later, as shown in the accompanying illustration, will consist of a platform, having on each side four enormous hollow wheels, which will support it at a height



M. BAZIN'S ROLLER STEAMER.

of from 21 ft. to 23 ft. above the surface of the water. About a third of the wheels will be submerged. The shafts for transmitting the rotary movement to the wheels will pass below and across the platform and, like the wheels, will be of steel. On the platform will be placed the engines, boilers, passengers' cabins and the dining and other saloons. The wheels will be about 24 yards in diameter and will have a revolving circumference of about 75½ yards. A new hydraulic rudder, always in action, has been invented by M. Bazin. It consists of a vertical column at the stern of the vessel. From this movable column will escape a powerful jet of water. It is claimed that with this rudder a vessel will be able to turn in her own length, and to dispense with the services of a tug in going to her anchorage.

M. Bazin argues that in order to obtain a maximum rate of speed there must be a corresponding relation between the rotary force and the propelling force, and his roller steamer will, therefore, be provided with two independent engines, one to propel the vessel forward by means of a screw, the other to give the wheels their rotary motion. The correct correlation being established, it is estimated that sixty per cent. of the revolution of the wheel will be forward. Thus, with a wheel of 75½ yards circumference, revolving at the rate of twenty-four revolutions a minute, the maximum number of revolutions, the vessel would cover a distance of 1,087⅕ yards a minute, or about 37 miles, that is, 32·22 knots an hour. The voyage from Havre to New York would, at this rate, occupy a little under 100 hours.

Among other advantages may be mentioned the small amount of rolling that, it is said, would take place, even if the wheels on one side were forced to the level of the water; the ease with which repairs to the hull could be undertaken, docking being unnecessary; and injury to a wheel even could be made good without putting into port, the damaged wheel and its corresponding wheel on the opposite side only being stopped while the repairs were executed, the remaining wheels continuing their functions.

THE BLACKWALL TUNNEL, LONDON.

ACCORDING to the Daily Graphic, Sir Joseph Bazalgette's original design for the tunnel was to make it of three tubes, two for vehicles and one for pedestrians. When the County Council took the project over from the Board of Works, their engineer, Mr. A. R. Binnie, combined the three tubes in one, and a tube, 27 feet in diameter, it is which is now being thrust under the Thames very much as one thrusts a cheese scoop into a Stilton.

There are three kinds of excavation which are exemplified in the tunnel. The central portion under the bed of the river, which is naturally the most important, will be tunneled by the process known as the "shield" and compressed air; and this kind of work is the most difficult, as it is the most interesting. At each end of the portion of the tunnel so excavated are other lengths of what is known as "cut and cover" work, the passage being excavated in the ordinary way from the open air and then covered in. Lastly, we have the two ends of the tunnel formed of open approaches or sloping trenches, down which the roadway runs.

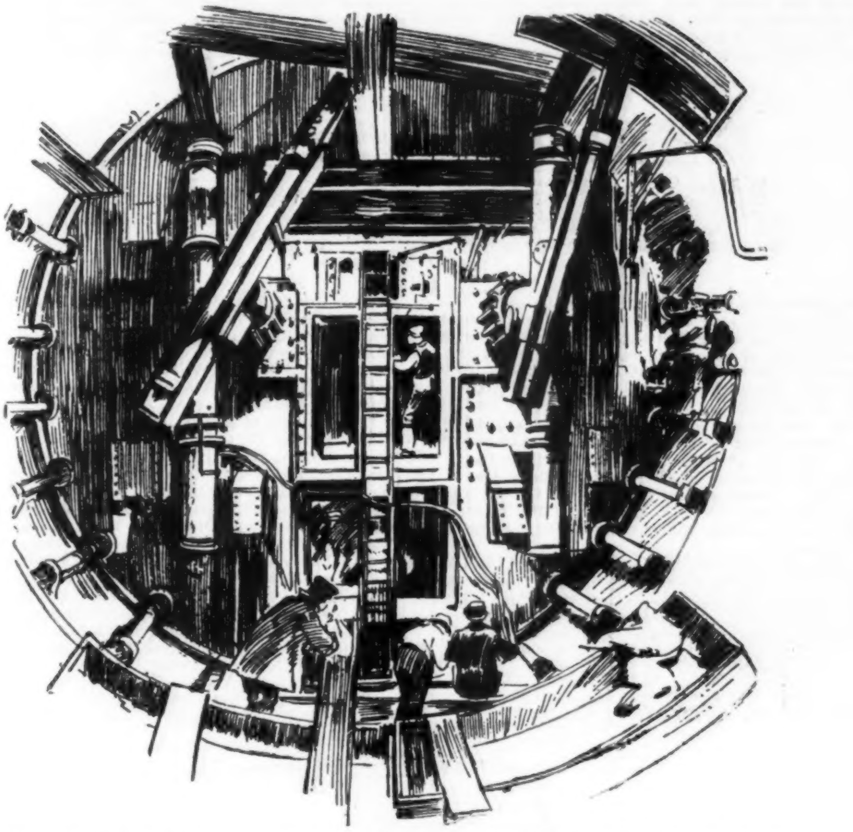
Now, to pursue for a moment our simile of the Stilton: Let the reader imagine the cheese standing on its end like a barrel and a small hollow to have been dug out of the middle of the top of the cheese already. Suppose we wanted to tunnel under this hollow, and were not permitted to start from the outside of the cheese. We could sink another deep hollow, on each side of the middle hollow, and then operating from the depths of these hollows push our cheese scoop or scoops until they meet underneath the level of the middle hollow, and that mutatis mutandis is what is being done at Blackwall. Only instead of one pit being sunk on either side of the river, there are two on each side, and all four of them theoretically in a straight line. These pits are sunk some distance below the level of the bed of the river, the boring "shields" are lowered down the outer ones, so that they are face to face with one another below the bed, and then with hydraulic rams they are thrust on and on until some day they will meet. It will perhaps be clearest to give the figures relating to the lengths of the different kinds of work being pursued at Blackwall at this point. The bridge starts on the northern side of the river from the East India Dock Road, and runs down the side of Robin Hood Lane, thence bending through a very flat S curve under the line of the Great Eastern Railway. After this it displaces a number of houses, and finally reaches shaft No. 1. Here it makes an angle, and runs to shaft No. 2, which is just by the side of the river. It goes underneath the river at right angles to the stream until it reaches shaft No. 3, also by the side of the river, makes a slight bend toward Greenwich Park and shaft No. 4, which is in a neighborhood pleasantly named Bugsby's Marshes, and so on to Blackwall Lane.

The figures relative to these distances are—starting from the East India Dock Road: Open approach, 785 feet; cut and cover tunnel, 436 feet; shield-driven tunnel, 821 feet to shaft No. 1; ditto, 447 feet 6 inches to shaft No. 2; ditto, under the river, 1,212 feet to shaft No. 3; ditto, 602 feet 6 inches to shaft No. 4; then a further section of either shield-driven or cut and cover for a distance of 611 feet; cut and cover, 335 feet; and lastly, an open approach for the south side, 800 feet. Under the river the tunnel is at a

dead level; from the river on each side it rises about one foot in thirty-five.

The sinking of the shaft from which the boring shield is to be pushed is itself a very interesting work. The shaft itself is a monstrous double ring of iron with a mass of concrete between the inner and the outer ring. It is 58 feet in diameter and 75 feet to 95 feet deep. Of course to sink such a tube into the earth as a whole would be impracticable. A small portion of it is constructed and then sunk by digging and working away the soil from under it, its own weight gradually forcing it down till its upper rim is level with the ground. Then another section was built up on top of the first, and a third on the top of the second, and so on until the whole 78 feet had gradually settled down as little by little the earth was excavated from under it. The tunnel, as it slopes toward the river, passes through holes in the sides of each of these shafts, and the shafts themselves when the tunnel is completed will contain staircases by which the tunnel may be reached.

There was another interesting engineering work indirectly connected with the sinking of the shafts, mention of which may appropriately be made here; it was the lowering of the enormous shield which is boring the tunnel. The shield (the Beach hydraulic shield) is a tremendously strong iron structure with steel rim, and it weighs 250 tons. The simplest plan would have been to put it together at the bottom of the wall-like shaft, but that would have delayed its construction until the shaft itself had been finished, whereas the engineers were anxious to have the shield ready to put into position as soon as the shaft was ready. The ponderous mass was therefore put together in a lumber framework near the brink of the shaft. When all was ready for it to be lowered into position, the dock and the shaft were both filled with water; the iron shield in its lumber frame was floated into the great circular well and dropped into position down below by the simple process of pumping out the water. Having got it down to the proper level, the next thing was to pass it through the side of the shaft on its way toward the river bed. It stood on edge like a huge tambourine at the bottom of a stove pipe, and through the stove pipe the tambourine had to be thrust with its cutting rim in front. But, as mentioned before, the stove pipes had been sunk with holes ready made in them—holes, of course, covered by iron plates, and these plates were then removed and the tambourine lifted into position.



THE BEACH HYDRAULIC SHIELD NOW AT WORK IN THE BLACKWALL TUNNEL, LONDON—AT THE BACK OF THE DRIVING SHIELD.

WORKING THE SHIELD.

At the back of the shield are hydraulic rams ready to thrust it forward through the soil at a pressure if necessary of 100 tons to the square inch, but besides the forward movement of the twenty-eight "jacks," there are other hydraulic operations coming into action. There are two engines called "hydraulic erectors." They are fixed up at the back of the shield, of which, however, a little further description is, perhaps, necessary here. The comparison of a tambourine is perhaps a little misleading, for it is when working more like a drum, with a face 27 feet 8 inches in diameter and 19 feet 6 inches long. About half way in the length of the cylinders are placed two bulkheads or diaphragms made of steel plates, with a distance of 3 feet between them. Suppose the shield now in a position for boring. The workmen pass through doors provided in the diaphragm, and attack the face of the earth exposed at the end of the cylindrical shield. The part of the cylinder forward of the diaphragm is divided up into twelve stories or compartments, just as a house is storied, and the men can therefore reach the whole face of the earth at once.

While the excavation is being carried on in the fore part the tunnel itself is being erected in the tail part of the drum by the hydraulic "erectors" of which we have spoken. Each of these will pick up a section of the iron lining of the tunnel and thrust it up into position—one working on the right hand and one on the left. These iron sections have strong flanges and machined joints, and are riveted together into a gigantic circular iron subway. A suitable length of the tunnel having thus been built up inside the shield, and a corresponding length having been excavated in front of the diaphragm, it becomes necessary to move it forward; and now the twenty-eight hydraulic rams come into play. They are fixed round the inner circumference of the shield, pressing against the completed ring of tunnel lining, they force the whole shield forward with a pressure of 2,800 tons into the hole excavated. The completed ring of the tunnel is left behind, and the cylindrical shield is shoved off the tunnel lining, just as the outer tube of a telescope slides off the smaller one within. As a matter of fact, of course, the shield itself supplies a cutting edge.

COMPRESSED AIR.

The whole of the working of the tunnel up to the present time has presented the spectacle of difficulty after difficulty ingeniously and successfully overcome. Once already the giant Greathead shield has come perilously near to collapse. It encountered a mass of cement-like material as hard as rock, and, being pushed ever forward by its persistent rams, crumpled up at its edge one fine morning like so much cardboard. That accident cost £3,000, and delayed the boring for five months. A portion of this inimical cement is still kept in the office of the works as a memento, together with a number of other curiosities, such as some curious small-bowled pipes. At this new year's time the most dangerous and awkward part of the job is approaching, for the shield is under the river, and is nearing that which will be the most dangerous and difficult part—the water-bearing strata. The tunnel will have to be carried for a considerable distance through a bed of loose gravel and sand, of which there will be no more than seven feet between the crown of the working and the river bottom.

Through this the water of the river would pour in such quantities that the workings would soon be drowned out were not special means taken to prevent it. These special means consist in the use of compressed air. For a considerable distance the tunnel is filled with air pumped in until the pressure within the section is 26 lb. to 28 lb. to the square inch above the ordinary atmospheric pressure, and this pressure is sufficient to keep the water out. Entrance to this "compressed air" part of the tunnel is obtained through what is called an "air lock," a contrivance easily understood, since it is similar in principle to that of an ordinary water lock. That is to say, it is a cylindrical chamber with an air-tight door on either face of it. When any one wants to go into the tunnel he goes into the cylinder through the outer door, which is then closed, and compressed air allowed to flow into the chamber from the tunnel until the pressure is the same in the chamber as in the tunnel. In coming out, of course the procedure is reversed. Working in compressed air is, of course, a somewhat dangerous and difficult business. Full-blooded people, or people suffering from colds, are apt to find the sensation distressing, and some people cannot stand it at all. Thin-blooded people support the unusual condition best, but it is safe for no one to work more than a short number of hours a day. One of the odd phenomena is, however, that the best restorative to men to whom anything has happened is the compressed air itself. In order to provide these conditions a "medical air lock" has been built above ground into which men are taken in case of distress. The chief danger, however, is that of chill, for the temperature of the body rises slightly under the abnormal condition, and the men perspire very freely. The County Council have, however, built for the men large heating and drying sheds for themselves and their clothes. It is hardly necessary to say that the Council takes the greatest interest in the work, and the chairman of the committee which is responsible for it, Mr. William Bull, L.C.C., is a most indefatigable superintendent of it. There is hardly a disagreeable experiment connected with the peculiar conditions of the work which he has not made in his own person. Mr. John Burns, by the way, has been down, and while there laid a brick. The workman whose work it was looked admiringly on, and when it was finished guilelessly observed that "it was the driest brick he had ever seen laid!"

The newest piece of ingenuity for which the engineers of the tunnel are responsible is that of laying a kind of plaster at the bed of the river from the outside. It was feared that the pressure of the compressed air might itself co-operate with the watery soil to bring the water into the workings; and in order as far as possible to guard against this difficulty a bed of clay, consisting of many thousands of tons, is being tipped into the bed of the river from barges. The names most prominently associated with the great work of building the tunnel and meeting the hostile forces of nature with the defensive ingenuity of science, are Mr. A. R. Binnie, as engineer to the London County Council, and Messrs. David Hay and Maurice Fitzmaurice, resident engineers. Mr. T. H. Greathead is consulting engineer for the subaqueous and tunneling work. Messrs. Pearson & Sons are the contractors. Their tenders amount to £871,000.

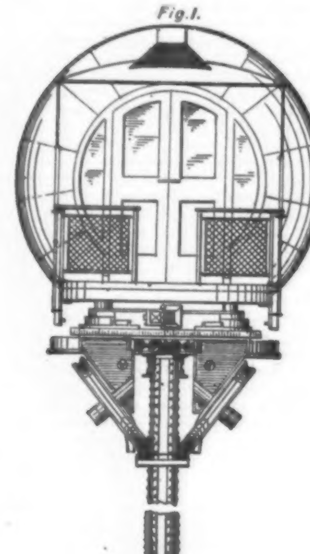
THE PROGRESS OF THE BLACKWALL TUNNEL—WORKING IN THE COMPRESSED AIR CHAMBER.

THE MEIGS ELEVATED RAILWAY SYSTEM.

IN July, 1894, the Massachusetts Legislature passed a bill incorporating the Boston Elevated Railway Company, which bill has been approved by public vote of the city. The law of 1884 provided that the railways should not be built after the manner of the New York elevated railways, but according to the Meigs inventions. The new bill does not so definitely specify the Meigs system, but prohibits structures similar to those of the New York roads. The bill makes the company subject to all laws respecting railway corporations, provides for payment for land damages, and requires some return to the public for the franchise. In regard to the former bill, it may be noted that the railway act provides only for gauges of 4 feet 8½ inches and 3 feet, and the bill had to make the Meigs Company exempt from that clause, as otherwise the railway commissioners could not grant a location, the widest part of the Meigs' track being only 22 inches. Charles A. Whittier is president of the company; Joe V. Meigs, chief engineer; and Herman Haupt, consulting engineer.

The structure consists of a single row of posts or columns, Fig. 1, carrying a single line of girders. For country lines wood may be used, but for city lines, of course, only steel or iron is used. The columns are 18 inches by 12⅞ inches in section, built up of two channel irons and two plates. The interior is filled with concrete, the top of which is covered by a plate, upon which rests the friction bearing forming the support for the end of the top chord of the girder; the weight being thus carried by the concrete mass. The longer dimension of the column section is parallel with the line of way. The columns will be normally 24 feet 4 inches long, set 6 feet in the ground on a foundation of concrete or piling, and giving 14 feet clear headway under the girders. The columns will be 13½ feet to 45½ feet apart, center to center. The girders will be 12 feet to 44 feet long, according to location; they will be of the Warren or lattice girder type, 46 inches deep, the single panels of Warren girders being 4 feet long. The top and bottom chords, or booms, of the girder are each composed of a vertical plate and two angle irons. On the top chord are two angle irons placed to receive the longitudinal timber of the top rail, and the angle irons of the lower chord carry the longitudinal timbers for the lower rails, the trucks, or "bogies," straddling the girder.

Fig. 1.

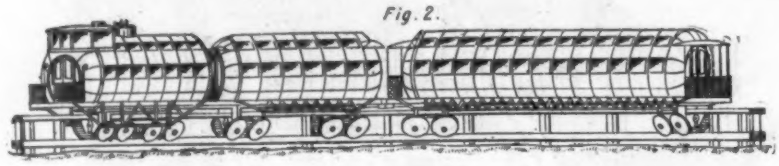


In an ordinary elevated railway the track is about 8 feet wide at least; that is over the sleepers, and not including the usual extra width of the footway for trackmen. There is therefore this continuous width—for the sleepers are very close together—of obstruction to light and air. Besides this, the track is carried by two lattice or plate deck girders 4 feet to 5 feet deep, and about 5 feet apart. With two tracks laid side by side, and with the further obstruction of cross girders over the columns, and of sleepers at crossover roads, etc., some idea of the general effect upon a narrow street may be imagined. In the line at Hoboken, N. J., an attempt has been made to reduce this obstruction by laying each rail upon blocks of wood resting upon brackets riveted between two deep channel irons, the sleepers being thus eliminated, and the channels forming inside and outside guards to each rail.

In the Meigs system, however, there is but one line of girders, Fig. 2, to each track, the depth being about 4 feet. The maximum width for each track is 17⅛ inches over the rails on the top chord, and 22½ inches over these on the lower chord. These lower rails are wooden longitudinals, with the top outer corner faced with angle irons fitting the V shaped rims or treads of the car wheels. The longitudinals may be beveled and carry flange rails for wheels with grooved treads. The upper rails are either wooden longitudinals faced with iron for the horizontal balance and driving wheels or may be flange rails laid on their sides. In this way the cars have a depth of 48 inches to resist derailment, instead of about 1 inch of a wheel flange, as in the ordinary system. The switching or shunting will be done by a pivoted girder. The inspection may, perhaps, be somewhat difficult, but maintenance repairs can be effected from a wagon with a platform adjustable at any desired height, such as is used by electric railway companies for repairs to the overhead wires.

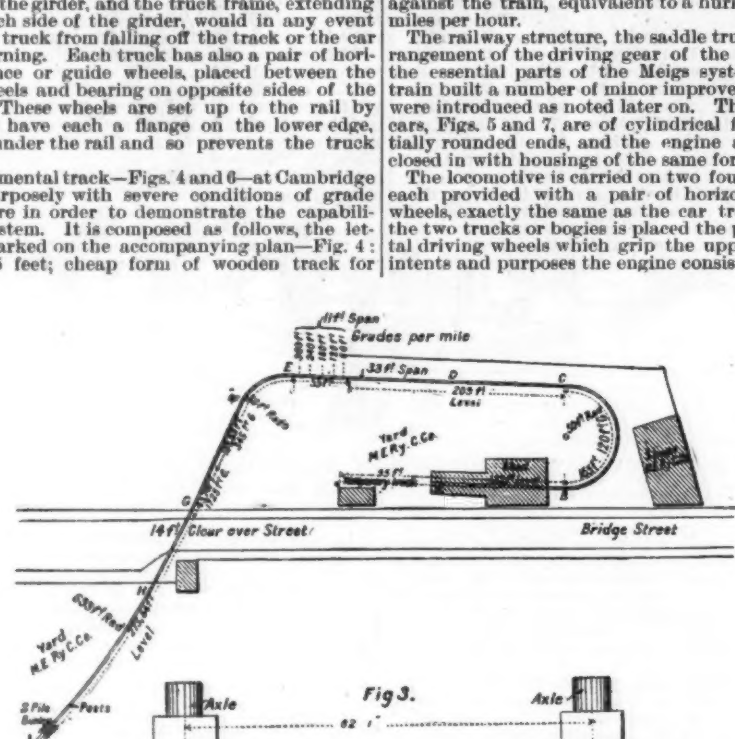
A feature of the Meigs system, which is equally as important as the single girder track, is the construction of the car trucks, "bogies," Figs. 3 and 7, which straddle the girder. Each truck has four loose carrying wheels with grooved treads, running on the lower chord of the girder, each wheel being carried on a short independent axle and being inclined outward from the rail at an angle of 45 degrees. This at first seems a rather unstable arrangement, but theoretical investigation and practical experiments have shown, it is said, that it is not objectionable. In the unlikely event of a wheel, or all four wheels, breaking or coming off, or part of one of the rails being removed, the car truck would merely drop a few inches until it rested upon the girder, and the truck frame, extending down on each side of the girder, would in any event prevent the truck from falling off the track or the car from overturning. Each truck has also a pair of horizontal balance or guide wheels, placed between the carrying wheels and bearing on opposite sides of the upper rail. These wheels are set up to the rail by springs, and have each a flange on the lower edge, which runs under the rail and so prevents the truck from lifting.

Fig. 2.



The experimental track—Figs. 4 and 6—at Cambridge was built purposely with severe conditions of grade and curvature in order to demonstrate the capabilities of the system. It is composed as follows, the letters being marked on the accompanying plan—Fig. 4:

O to A, 95 feet; cheap form of wooden track for yard use, with no iron rails. A to B, 132 feet; heavier wooden structure, with iron rails on upper and lower tracks; straight and level. B to C, 165 feet; similar construction, but on rather more than half a circle of 50 feet radius and a grade of 120 feet per mile. This curve is a very severe test of the engine, which, however, passes it very easily. C to E, 264 feet; wooden structure, straight and level, including a wooden truss girder of 33 feet span; followed by five wooden spans of 11 feet each, all on different grades changing abruptly, the grades being 60 feet, 120 feet, 180 feet, 240 feet, and 300 feet per mile. E to G, 181 feet; wooden structure from E to F, on a curve of 50 feet radius, nearly 80 degrees, with a grade of 345 feet per mile; then an iron structure with grades of 345 feet and 172 feet per mile. G to I, 276 feet; from G to H are two iron girders of 46 feet span, such as will be used for city railways. These cross the street, and are followed by an iron structure with short straight sections making a curve of about 700 feet radius. The total length is about 1,114 feet.

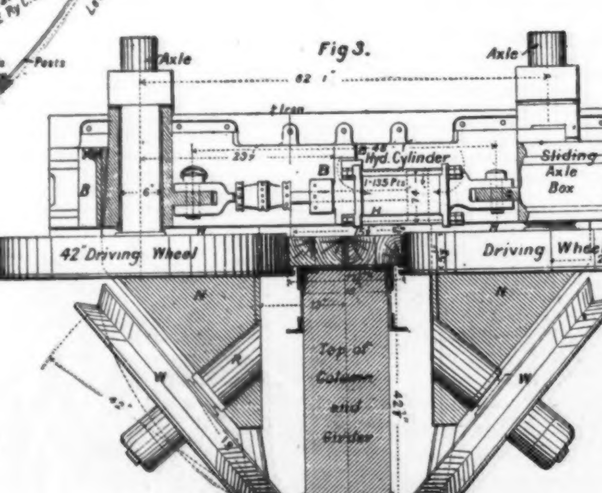


The iron girders, 46 feet long, are lattice girders built up of angles and bars, with angle iron diagonals under the bottom chord, and this was the character of the structure tested by General Stark for the railway commissioners. With a weight of 30 tons—cylindrical tanks filled with water—suspended by a chain from the middle of the girder, equal to a distributed load of 60 tons, the deflection was only 7-16th of an inch, and there was no permanent set. To test the lateral strength of the structure in the event of a heavy gale blowing squarely against the side of a train, a cable was attached to a timber on one side of the girder, and carried horizontally to the top of an A frame, and then down over a pulley to a platform loaded with pig iron. This gave a horizontal pull on the middle of the girder, and with a load of 5¼ tons the lateral deflection at the middle was ⅜ inch, the movement causing the columns supporting the girder to bend ⅛ inch at their tops. On the removal of the load the girder and columns returned to their normal positions. This would be the effect of a wind blowing at 33 lb. per square foot against the train, equivalent to a hurricane of over 90 miles per hour.

The railway structure, the saddle truck, and the arrangement of the driving gear of the locomotive are the essential parts of the Meigs system, but in the train built a number of minor improvements in detail were introduced as noted later on. The bodies of the cars, Figs. 5 and 7, are of cylindrical form, with partially rounded ends, and the engine and tender are closed in with housings of the same form.

The locomotive is carried on two four-wheel trucks, each provided with a pair of horizontal balancing wheels, exactly the same as the car trucks. Between the two trucks or bogies is placed the pair of horizontal driving wheels which grip the upper rail. To all intents and purposes the engine consists of a platform or flat car, upon which are mounted a boiler and a pair of horizontal stationary engines, so that the sizes of boiler and fire box are not limited by the frames as in ordinary locomotives. The boiler is of steel, 5 feet in diameter and 15 feet long, with 208 tubes 2 inches diameter and 7 feet long. The center line is 5 feet 1 inch above the floor. The fire box is 54½ inches long and 54 inches and 55 inches wide, with the crown sheet inclined downward toward the rear end, so as to keep it covered with water on grades as steep as 800 feet to the mile. Anthracite coal is used for fuel.

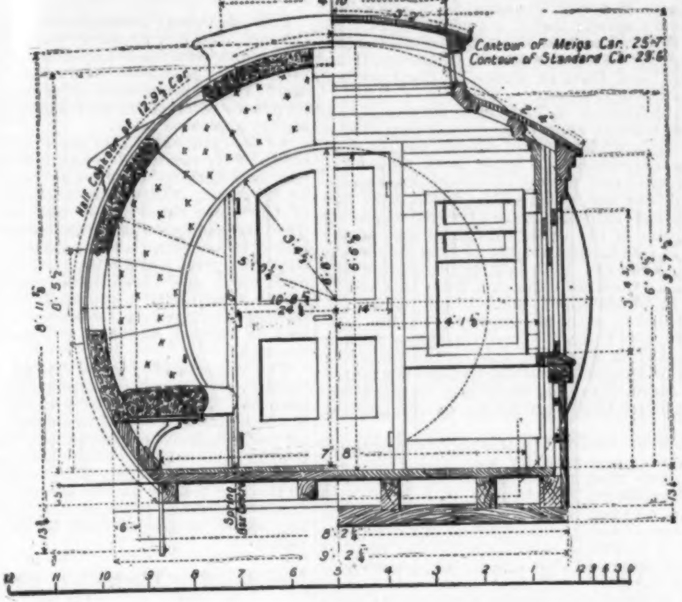
Fig. 3.



A peculiar feature of the engine, which is especially striking when seen at work, is that there are no connecting rods, but on the under side of each crosshead is a sliding box with a vertical pin, which is fitted into a horizontal crank arm on top of the 6 inch vertical axle the driving wheel. The cylinders are 16 inches by 22 inches, placed at the smoke box end, and having the

valve chests on top, in accordance with standard American practice. The cylinders are horizontal, and 61 inches apart between center lines. The piston rods carry large crossheads, each traveling on two heavy bar guides, and driving the wheels in the manner above described, the arrangement being that known

Fig. 5



as the "slotted yoke" connection. The link motion valve gear is used, the eccentrics and links being horizontal and under the crank arms, operating the valve rod through the intervention of bell cranks. The driving wheels are 44½ inches diameter, with cylindrical tires 6¼ inches wide, and flanges on the lower edge of the tires. At first it was not thought necessary to couple the drivers, but in practice it was found to be desirable in order to insure steadiness of the engine. Gearing has been adopted for this purpose,

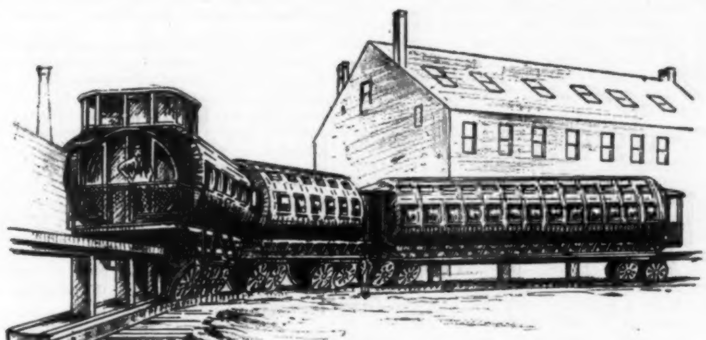


Fig. 6

there being a gear wheel on each driving axle and two intermediate gear wheels. The adhesion is obtained by hydraulic power, Fig. 3, each axle box being carried in horizontal slides and attached to the piston rod of a hydraulic cylinder, so that the pressure can be regulated according to the loads and the grades. The present engine can stop and start at will on a grade of 345 feet per mile, and sufficient pressure can be applied to crush the track itself. This pressure can be used as braking power. The blast pipe has a large nozzle, the exhaust being unobstructed.

The cylindrical form of the housing gives ample room inside for communication between the engine and tender and for attention to the machinery. At the front of the locomotive is the cab, being a raised platform inclosed, fitted with windows and covered by a monitor roof. From this station the engineman has a clear view of the track, and has ready to hand all the levers for controlling the engine, brakes, etc. The fireman's station is at the rear end, but, as before mentioned, there is convenient communication. An objection that may be made to the position of the cab is that it is liable to injury in case of any slight collision. It sometimes though rarely happens on elevated railways that in foggy weather a train will run into another which has been slow in getting away from a station. Owing to the low speed at such times there is usually very little damage done, except to the rear platform of the car, but the driver of a Meigs engine would stand a fair chance of being injured, or at least cut by broken glass, as he would be right in front of the engine instead of being protected by the length of the boiler. This objection might be eliminated by extending the front platform and building it heavily. The cab is reached by steps, and is accessible from doors in the front of the housing, opening out on the front platform or from the interior of the engine.

The engine is 29 feet 3 inches long over all and 7 feet 6 inches wide, weighing 30 tons. Next to the engine is the tender, carried on two trucks of the type already described and having a cylindrical housing. It contains two cylindrical water tanks with a capacity of 1,800 gallons each, and there is ample coal space. The size of the tender is 25 feet 9 inches long and 7 feet 6 inches wide across the floor, and its weight is 14 tons. On the experimental train there is no brake except the controllable grip of the driving wheels, which is amply sufficient as far as power goes, but for actual operation of trains some form of continuous automatic brake would be used, and it has been proposed to use a hydraulic brake acting on the balance wheels, and causing them to grip the upper rail.

The underframing of the passenger cars consists of a pair of Warren girders about 18 inches deep, making a strong construction to resist collisions. The body is of the cylindrical form with rounded end corners, and has end doors and platforms. The body framing consists of light ribs of T iron, bent to a circle 10 feet 8⅛ inches diameter, the spaces between being filled in by panels of galvanized iron, lined with asbestos inside, and sheathed with wood on the outside. The car is 51 feet 2 inches long over all, 7 feet 6 inches wide on the floor, and weighs 17 tons. The floor is of ⅝ inch floor boards, laid diagonally, and nailed to an under floor of 1⅛ inch planks carried by floor beams of 5 inch channel irons. The car is very roomy and comfortable. Along each side is a row of seats as in street cars, but instead of the entire middle portion of the floor being left unoccupied, there is a single row of seats with the backs alternated, so that passengers face to right and left alternately. With this arrangement the car has seating capacity for eighty-four passengers, as compared with forty-eight on the cars of the New York and other elevated railways. The windows have hinges instead of sliding sashes,

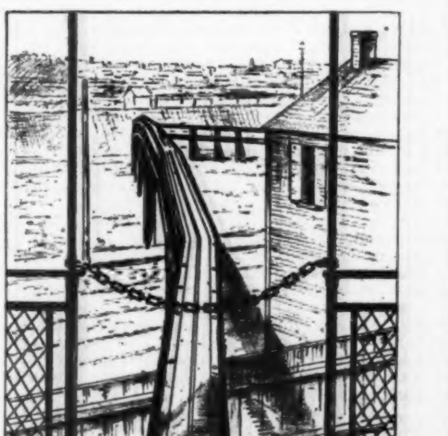


Fig. 7

and by a device invented by Capt. Meigs, the window can be opened at either end, so that in whichever direction the car is moving the "rear" end of the window can be swung out, hinging at the "front" end, so that the passengers can have fresh air and at the same time exclude dust and cinders. The upholstering is carried right to the window space, and the sash fits against it, so that there is no draught when the windows are closed. A row of smaller windows is placed on each side of the upper portion of the car, being provided with curtains to shut out the sun. Ventilation is provided by an air pipe or trunk along the top of the ceiling having trumpet-mouth ends outside the car and having valves in the lower part to regulate the draught. Semicircular pipes against the sides have openings under the seats and connect with the longitudinal trunk, so that as the car moves, the interior air is drawn out from the top and bottom. Each end of the car has double swing doors opening on to an end platform, with the usual arrangement of roof and railings. The platform gates, however, instead of opening by swinging back on the platform, as on other cars—which is very troublesome when the cars are crowded—are made to slide vertically downward, being raised again by cords passed over a drum operated by springs. The upholstering is in red plush for the seats and old gold plush for the sides and ends. Steam heating pipes may be carried along under the seats, and lamps hung from the roof in the usual way.

The car body is not attached to the truck by means of a center plate and king pin or pivot, as in the ordinary type of car, with which arrangement it not unfrequently happens that in case of accident the car body is knocked off the trucks. Instead of this, another of Captain Meigs' inventions is used. Attached to the under frame of the car, over the truck frame, are four hollow vertical cylinders, with the bottom diameter reduced by an interior flange. These carry a turntable which rests on two semicircular slides or bearings on the truck frame. On the truck frame are four vertical hollow cylinders, with the exterior diameter longer at the top. The inner flanges of the upper cylinders engage below the outer flanges of the lower cylinders, so that it is impossible for the car body to lift off the trucks. Coiled springs are placed in the cylinders. A rim on the turntable also engages the curved truck bearings. The usual form of king bolt connection is used for pivoting the truck or "bogie." The car couplings are an adaptation of the Miller automatic link coupling, as now almost universally used on the best passenger cars, but are controlled by the engineman by means of hydraulic connections.

In regard to speed, the existing line is too short for any high speeds, but the 50 foot curve has been easily taken at a speed of 15 miles per hour on the down grade. Elevated railways as now built are but little hampered by snow, as it does not lie deep and is easily disposed of, and in Mr. Meigs' system there is even less space for it to lodge.—The Engineer, London.

THE HISTORY OF THE FOUR WHEELED BOGIE.

By CLEMENT E. STRETTON, C.E.

THERE are few subjects connected with the history of the locomotive engine which have at various times engaged more attention or have caused so much acrimonious discussion as the history of the "bogie engine," and more especially the question as to whether the credit for its introduction belongs to England or America.

The writer, viewing the matter simply from the position of an impartial, independent historian, has not accepted the claims or statements of either side, but has fully investigated the whole of the reliable evidence and official records, with the following results:

As early as the year 1800 the Merthyr Tydfil tramroad was opened in South Wales, and in order to convey long bars of iron and also timber, wagons were constructed in pairs coupled together by an iron draw bar, having a joint at either end; these wagons had no sides, but in the middle of each there was fixed a center pin, upon which worked a cross beam or "bolster," upon which the timber or bars of iron were placed. Of course, it will be at once seen that these early wagons were not actually "bogie" vehicles, and that they were in use before even the first locomotive engine had ever run upon rails, yet we cannot upon examination fail to see that they contained all the essential principle of the "bogie." They allowed a very long load to be conveyed round sharp curves, and permitted the wheels under the two trucks to follow the curve of the rails; now the most improved bogie vehicles of to-day simply carry out the very same principle. There can be no question as to the practical value of these early bogie wagons, when it is mentioned that some of them were in use from 1800 to 1875, and that two of them were sent from South Wales to the Chicago Exhibition of 1893.

In 1813, Blackett and Hedley constructed two engines for working on the Wylam Colliery line, near Newcastle-on-Tyne. The first of these was named "Puffing Billy," the second "Wylam Dilley." They both ran upon four wheels, and were successful, so far as conveying coal cheaper than by horse power, but their weight broke the cast iron plate rails to such an extent that it became necessary to carry half a dozen rails upon each engine to replace those which might be broken during the journey. To prevent the breaking of the rails, Blackett and Hedley placed each engine upon eight wheels, arranged exactly like the Merthyr Tydfil timber wagons; they put the wheels under two separate frames or trucks, in other words, they placed their engines upon two four-wheeled bogies in the year 1815. These two double bogie engines worked successfully from 1815 to 1830, when the railway was relaid with stronger rails, flanged wheels were employed, and the engines were again returned to four wheels, and one of the engines is now preserved at South Kensington museum and the second at the Edinburgh museum.

Now, here we have ample proof that two engines, each having two four-wheeled "bogies," were actually at work in England for fifteen years before 1830, and before any bogie engine had been tried in America or other part of the world.

On the other hand, it will be seen that the English abandoned the use of the bogies on these engines in 1830, and, therefore, that they either did not observe or did not appreciate the value of the "bogie," for it will be found that the celebrated "Rocket," "Planet" and other engines of the period had the rigid wheel base.

During the year 1831 Messrs. Stephenson & Co. sent

out four engines to America, named "Whistler," "Delaware," "John Bull" and "Stephens," which had its name changed to "John Bull." Mr. Bury, of Liverpool, also sent his well known "Liverpool," of 1831, but experience quickly proved that the American railways were not so strongly laid as were those in England, for engines which were satisfactory in this country were in the United States found too heavy or had difficulty in passing round very sharp curves. The engine Stevens' "John Bull," running upon the Camden and Amboy Railroad, was within a few weeks of its arrival fitted by the Americans with an extra pair of wheels in front attached to a swiveling frame; in other words, a two-wheeled pony truck, and it is a matter of much interest that this old engine has been so well preserved in working order that at the commencement of the exhibition of 1893 it ran in steam with its train from New York to Chicago, a distance of 913 miles, a remarkably good performance for an engine sixty-two years of age.

Early in the year 1832 Mr. Horatio Allen, of New York, placed an engine upon the South Carolina Railroad having two boilers and a chimney at either end. It was carried upon two four-wheeled bogies, in a manner similar to the English engines of 1815.

Thus far it will seem that we have before us many steps and links leading up to the bogie engine, but just the exact thing required had not been produced. In August, 1832, Mr. John B. Jervis, the engineer of the Mohawk & Hudson Railroad, had an engine built in America for that line; it was named "Experiment." It had a regular four-wheeled leading bogie placed under the smoke box and a single pair of driving wheels placed at the trailing end. This "Experiment" of 1832 is, without doubt, the forerunner of all the bogie passenger engines of to-day; it proved so satisfactory that "bogies" were placed under several of the previous four-wheeled engines, and the bogie (or, as the Americans always call it, the truck) has ever since been adopted and used in the United States. In 1833 Messrs. Stephenson & Co. constructed an engine named "Davy Crockett" for the Saratoga & Schenectady Railroad. This engine had a leading bogie and single driving wheels, and was almost exactly similar to the "Experiment" of Mr. Jervis. Some persons have stated and claimed that the English "Davy Crockett" was built to the order and design of Mr. Jervis, others have maintained that it was designed at Newcastle. This point, it will be seen, is of practically no importance in the chain of history, for when it is proved that the first engine of the class was built in 1832, it matters but little who built an almost exact copy of it about a year later.

During the time that Stephenson was building the "Davy Crockett" and some other leading bogie engines for America, Messrs. Carmichael & Co., of Dundee, were busy constructing three engines for the Dundee & Newtyle Railway in Scotland. These engines had a single pair of driving wheels placed in front and a four-wheeled bogie at the trailing end. The first of these engines was named "The Earl of Airlie," and was put to work in September, 1833. These three locomotives were consequently the only ones working in Great Britain with a "bogie" at that time.

When the Birmingham & Gloucester Railway was opened it was found that no English engines could run up the Lickey incline of 1 in 37. Eight American engines were, therefore, supplied in 1840 by Norris & Co., of Philadelphia. They all had the leading bogie and a single pair of driving wheels, and were then the only leading bogie engines in this country.

Until the year 1874 it may be said that the bogie, either for engines or carriages, found very little favor in this country, but in that year the introduction of American Pullman car trains upon the Midland Railway proved to all impartial persons that bogie coaches ran far more steadily than either four or six-wheeled English vehicles.

About the year 1876 several of the English railways constructed express engines with leading bogies, and this pattern has gradually become more and more popular and successful, until now it may be said that the bogie has been adopted by nearly every line of importance in Great Britain, except the London & Northwestern.

From the particulars above given it will be apparent that the "bogie" had its origin in England, but that its general adoption for passenger engines commenced in America in 1832, and that between the years 1876 and the present time the bogie has been brought back, so to speak, to this country, and now it is easy to see that very few more passenger engines will be built in Great Britain without a bogie.—Locomotive Engineers' Journal, Leeds.

EXPLOSION IN MINES.

IN a lecture on some modern developments in explosives, given at the Society of Arts on December 17, Prof. Vivian B. Lewes threw out a suggestion as to the cause of explosions in dusty mines free from fire damp, which explains the anomalies which have presented themselves in several recent explosions.

It was pointed out that until quite recently explosions in mines were always attributed to the accidental ignition of mixtures of air and methane, to which the name of "fire damp" is given, and undoubtedly this cause is the prime factor in this class of disaster, and the introduction of such precautions as safety lamps at once brought about a considerable reduction in the number of explosions taking place. Many disasters, however, still continued to occur under apparently mysterious circumstances, the conditions being such that any large proportion of methane in the air of the mine appeared practically impossible, but investigations of such explosions showed that coal dust in a dry and finely powdered condition had generally been present in the mine at the time of the explosion, and the coked residue of this dust was found afterward on the surface exposed to the explosive wave, and years of experimental investigation by scientific men of the greatest ability proved the fact that air containing so small a proportion of methane as to be itself perfectly non-explosive becomes a good explosive again when holding dry and finely divided coal dust in suspension, and within the last few years explosions having taken place in mines which have always been celebrated for their freedom from any trace of methane. Further experiments have been made by Mr. H. Hall and Mr. W. Galloway, who have shown that the violent ignition of dust-laden air is possible by a blown-out shot, even if free from any trace of marsh gas, and there is evidence to show that the explosion is developed in throbs or waves.

It is therefore found that the explosions in mines may be brought about, first, by the ignition of a mixture of methane and air, in which the former rises above a certain percentage; secondly, by mixtures of air, coal dust, and methane, in which the amount of the latter may be excessively small; lastly, by mixtures of coal dust and air. With regard to these explosions caused by coal dust and air alone, the Royal Commission on Explosions from Coal Dust in Mines, in their second report, published this year, say:

"On a general review of the evidence on this point, we have no hesitation in expressing our opinion that a blown-out shot may, under certain conditions, set up a most dangerous explosion in a mine, even where fire damp is not present at all, or only in infinitesimal quantities; and while we are prepared to admit that the danger of a coal dust explosion varies greatly according to the composition of the dust, we are unable to say that any mine is safe in this respect, or that its owners can properly be absolved from taking reasonable precautions against a possible explosion from this cause. But even if we had been able to come to a different conclusion, and to agree with the minority of the witnesses examined, who think that coal dust alone cannot originate an explosion, we would still have to call attention to the serious danger which results from the action of coal dust in carrying on and extending an explosion which may originally have been set up by the ignition of fire damp."

One of the most interesting and instructive explosions which have taken place recently was that which occurred a little more than a year ago at the Camerton Collieries, Somersetshire, in which, as far as investigation could go, no trace of combustible gas could be found in the mine at any period prior to the explosion or subsequent to it, and in which everything pointed to the explosion being entirely due to the presence of dry coal dust in the air.

Of absorbing interest, also, are the experiments made by Mr. Hall at the latter end of 1892 and the early part of 1893, and reported upon by him to the Secretary of State on January 23, 1893, in which he shows by conclusive experiments that dry coal dust under conditions frequently present in coal mines, and in the entire absence of fire damp, may be inflamed by a blown-out gunpowder shot, and cause a disastrous colliery explosion.

The evidence which can be collected from the investigation in the Camerton disaster, and from Mr. Hall's experiments, point to a cause for such explosions which has apparently been overlooked, and which Prof. Lewes thought worthy of the gravest attention. Both at the Camerton Colliery and in Mr. Hall's experiments powder was the blasting agent used, and such powder as is employed for this purpose gives among the products of combustion nearly half the volume of permanent gases in the condition of carbon monoxide, methane, and hydrogen.

In the Camerton explosion, it seems probable that about 1¼ lb. of such powder was used in the shot which caused the disaster, and this quantity of powder would give, roughly, a little over three feet of inflammable gas, which when mixed with pure air would give over 10 cubic feet of an explosive or, at any rate, rapidly burning mixture, and experiments which have been made upon the effect of fire damp and dust combined in causing colliery explosions show conclusively that even when the fire damp is present in such minute quantities as to form a mixture very far removed from the point of explosion, it still makes the mixture of coal dust and air highly explosive; and from experiments which Prof. Lewes has made, it is clear that traces of carbon monoxide will do exactly tne same thing when the air is laden with coal dust, while the temperature of ignition is slightly lower than with methane, so that in the case of the Camerton Colliery, it being perfectly well ascertained that the air was charged with coal dust, the probabilities are that not 10 feet, but a far larger volume of explosive mixture was formed by the rapid escape of the products of combustion into the coal-laden air; and this being ignited, either by the flame or red hot solid products driven out into it by the blown-out shot, would initiate a considerable area of explosion.

The classical researches of Prof. H. Dixon have shown that hydrocarbons and, probably, carbon burn in air to carbon monoxide, and that this carbon monoxide will not form explosive mixtures with air, or even with oxygen, if they are absolutely dry; but if water vapor is present, they explode, owing to the oxidation of the carbon monoxide to dioxide, causing the propagation of an explosive wave, which reaches its maximum velocity when the percentage of water vapor is between 5 and 6 per cent., and inasmuch as the air of the mines would always contain some moisture, and as the products of combustion also would give a large volume of water vapor, these requirements would be amply fulfilled.

Still more conclusive on this point were Mr. Hall's experiments. In these a charge of blasting powder was fired from a cannon suspended in a shaft, the air of which was proved by careful chemical analysis to be absolutely free from any trace of combustible gas.

In order to get some idea of the condition of the air inside the pit during the explosion, samples of air were taken and were analyzed. Two brass tubes were fastened to the rope that was used to lower the cannon, one twenty yards from the bottom, the other forty yards from the bottom.

These tubes were so arranged and constructed that the explosion, as it passed the tubes, unsealed the outlet pipe, and the escaping water sucked in a sample of air which was trapped by a special arrangement, and kept in the tube until the rope could be wound up. By this method it was intended that the sample of gas taken should represent that state of the air while the flame was passing or directly afterward.

The tube nearest the bottom, as the analysis will show, did partly collect the gas in the above condition. The tube at the top, however, commenced to act prematurely, and was probably started by the sound wave which preceded the explosion. This tube simply contained ordinary air.

The following is an analysis of the gases found in the lowest tube:

	Per cent.
Oxygen	3·9
Nitrogen	75·9
Carbon dioxide	12·1
Carbon monoxide	8·1
	100·0

This ingenious arrangement was due to Mr. W. J. Orsman, and it is probably the first successful attempt which has been made to get a sample of gas during the progress of explosion, and there is not the slightest doubt that the presence of such an amount of carbon monoxide converts mixtures of coal dust and air into a highly explosive body.

As the explosion takes place, and as the carbon monoxide ready produced is oxidized to carbon dioxide by the action upon it of water vapor present, and also by its direct combustion with oxygen, the hydrogen of the water vapor is set free, while the heated coal dust also yields certain inflammable products of distillation to the air, and partial combustion also of the coal dust gives a considerable proportion of monoxide once more, and these driven rapidly ahead of the explosion form with more coal dust and air a new explosive zone, and so by waves and throbs the explosion is carried through the dust-laden galleries of the mine.

The experiments made by Mr. Hall, and investigations in various colliery explosions, make it abundantly manifest that no explosive should be licensed for use in mines unless it can be absolutely proved that it gives off no inflammable products of combustion. The following table will show the results given by some of the explosives most largely used, which point very clearly to the fact that, with the exception of the Sprengel explosives, such as roburite and nitroglycerine, none of the bodies in use conform to this important requirement.

PRODUCTS OF COMBUSTION FOR BLASTING EXPLOSIVES.

Powder.	Carbon dioxide.	Combustibles. Carbon monoxide.	Combustibles. Hydrogen and marsh gas.
Gunpowder	50·6	10·5	3·1
Blasting powder	32·1	33·7	7·9
Sprengel explosives—			
Roburite	32·0	nil	nil
Ammonite	33·0	nil	nil
Nitroglycerine explosives—			
Nitroglycerine	63·0	nil	nil
Gelignite	25·0	7·0	nil
Carbonite	19·0	15·0	26·0
Blasting gelatine	36·5	32·3	8·6

While not only these considerations, but Mr. Hall's experiments, point to the absolute necessity of legislative enactments at once forbidding the use of blasting powder in any coal mines, no matter how free they may appear to be from fire damp or from dust, if the returns made as to deaths caused by gunpowder and other explosives in mines for the year 1893 are examined, it will be clearly seen that the exclusion of gun powder, in handling alone, would do away with 80 per cent. of the accidents. So that if explosives of the Sprengel class were employed, accidents due to the explosives used would be practically eliminated from the mining death roll; and it is only a question of time as to when England will follow the action of France and Germany in altogether prohibiting the use of blasting powder in dusty mines.

HOUSE DECORATION.

By Miss G. JEKYLL.

"HOUSES are built to live in and not to look on." Happily the succeeding phrases modify the severity of the opening sentence of this well known essay, and indeed it is belied by the obvious beauty, both within and without, of the houses that remain to us of Bacon's time.

Looking at an ordinary dwelling house of this period, one cannot help feeling how simple and straightforward a thing it is to build a house, and a house not only sound but beautiful. One sees the material of the district, whether wood, or stone, or brick, used with a quiet sincerity of purpose that in itself insures that the building shall be good to endure and good to look at. It stands with grace and dignity, without affectation, without effort, without any of the errors or misconceptions that disfigure so much of modern work. On entering, one feels a sense of comfort, of repose, of quiet enjoyment to eye and brain, a warm welcome of delightful beauty. This is a real house; it is not a box cut up into compartments, it is not an imitation of something that it is not, with a painful sense of straining to look something like that wrongly desired ideal, it is not any one of the hundreds of ugly unrealities that the misdirected ingenuity of constructors and decorators has invented for the discomfort of those who are to live in the dwellings of to-day. These good old houses delight and satisfy not only those who in matters of fine art have eaten of the tree of knowledge of good and evil, but those also who only dimly know why, but who nevertheless feel that right is right and that simple beauty is satisfaction.

When one thinks of house decoration in anything like a broad sense, it must be allowed that it includes the details of the construction of the building itself and its furniture and fittings; in short, everything that is seen, and is capable of being treated well or badly. In going through one of the good old houses one is struck at every point by the simplicity of the means employed, and by the unaffected fitness of the result, and in considering decoration generally, it is strongly borne in upon one's mind that these are the conditions, indeed, almost the only essential conditions, to produce the best work. By simplicity must be understood simplicity of intention, or oneness of purpose; the determination to do the best and right thing in the best and most suitable way. The best way may be a hundred ways, but it is always the way that is the most fitting.

There is a best way for the palace and a best way for the moorland hut, and a best way for every lir

termediate gradation of building, whether for habitation or for any other use. But in all cases to be the best possible it must show these precious qualities of simplicity of intention and of absolute fitness or suitability to its purpose. A modern art critic deplores the loss in painting of the simple English charm, such as we see in the works of Reynolds, Gainsborough, Romney, Morland and others of their time; so it is also in house decoration. The good old houses were full of this charm; thoroughly English, genuinely homelike, absolutely satisfying and enjoyable. From roof to cellar rightly built with the best available material of the district; the work done by the laborers and craftsmen of the place, thereby securing those valuable local traditional ways of handling material and of treating detail that give such individual interest to the houses of a county or district.

Perhaps it was easier for our forefathers to build and decorate well and simply than it is for us. They knew enough and not too much; there were fewer distractions, fewer royal roads to non-success. To take an instance from one branch of house gear as a text for the whole, the ironmonger's pattern book did not exist. Locks, latches, hinges, bolts, casements and their fittings, firebacks, andirons and any other ironwork, these were all wrought by the local smith. Each piece is right and beautiful, bearing witness after two centuries to the thought and care of the skilled craftsman, and showing how he strove to make it serve its purpose in the simplest and best way known to him.

The pattern book is doubtless bound to exist, as a natural outcome of trade competition, division of labor within trades, and the general hurry of modern life; but though it may fulfill the wants of the impatient and unthinking many, it can never supply the desires of those who think that the house they are to live in is worthy of care and thought in every part. The beautiful details of well thought out handwork are seen throughout the old house of two hundred to three hundred years ago. The walls are hung with woolen tapestry worked by the women of the family and household. The fleeces were grown and spun upon the place and probably dyed at the nearest country town. The beds have needlework hangings of the same dyed worsted, worked on linen in boldly innocent designs of leaf, flower and scroll of the best possible effect. Always the same intention visible: to do good work by simple everyday means; thought and labor and patient industry given unsparingly, showing reverence to old tradition, though not slavishly copying it when new conditions demanded new treatment.

All done without strain, without affectation, no trying to be original or eccentric or new, or unlike anything else. Does not the decorator of to-day too often err just in these directions by trying to exhibit cleverness, or originality, or to awaken surprise, or to deceive the eye, and above all to produce something new? In the modern sense, indeed, decoration has too often for its object the covering up of all the structural necessities of a building, and tries to make everything look like something that it is not; paper to look like leather, like marble, like wood, like anything but paper. One sees curtains hung as portieres where no doors are, or draped round a mirror, which is there only to persuade the eye that there are spaces beyond. The effort to outdo in originality can produce most comical as well as deplorable results, but perhaps passing fashion is the worst enemy of wholesome decoration. Let us be thankful that the abundant peacock's feather and the Japanese fan have passed into the limbo of things "gone out," though the paper umbrella still lingers in some empty grates. Day by day some new frivolity arises to shock and irritate the sober decorator. It is useless to admonish where such taste is in force, it is better to pass on and try and do some good simple work; "Ephraim is joined unto his idols; let him alone."

It is sad to think of all the money and labor wasted, and the bad taste displayed in pursuing false ideas. Too frequent is the idea of variety. Do we not know the house with a Palladian hall, leading to a Louis Quatorze drawing room; the Henri Quatre dining room and the Francois Premier boudoir; the Japanese library; the early English billiard room; the Italian loggia leading to the Dutch garden! One imagines a perfect nightmare behind the scenes; a Queen Anne kitchen; an Egyptian scullery; a Byzantine servants' hall; an Assyrian still room; and a Carthusian coal cellar! Then the idea of change. Because for a series of years the decoration of a room was perhaps red, when it has to be renewed it must be green. The owner says, "Of course red suited the room best, and we all liked it red, but now that the chance occurs it seems a pity not to have something different." Is this decoration?

One of the great modern stumbling blocks is trade competition and advertisement. "Old English" furniture is offered in stained deal at 3s. 6d. per square foot, in oak (American wainscot), 5s. to 6s. We see the work of the fine old craftsmen being starved out by trade; chairs and tables sweated out at so much a hundred, twice as many bad chairs produced by machinery as there are people to sit on them, and badly made of bad material! These are the objects commonly offered to buyers of furniture and decorations. It is not that there are no good and conscientious workmen. There are masters and men in every trade the excellence of whose work has never been surpassed, but to the ordinary buyer they are scarcely accessible. Competition has so far flooded the market with second rate wares of specious appearance, intended to look better than they are, and it is so convenient to the bulk of the buying public to accept the objects offered, that year by year the evil only becomes aggravated, and at the same rate it becomes more difficult for the would-be buyer of simple and good work to come face to face with its actual maker. Look at one trade as an example. You want a picture frame carved and gilt. You see over a shop "Carver and Gilder." In many cases the legend is a pure survival. In most shops with this superscription they gild only; in a few they carve; in some they neither carve nor gild. If you insist on a carved frame of a certain class it is perhaps sent to Florence, or it is done by a Florentine workman in the East End of London.

In Italy a carver and gilder still carves and gilds. His designs and methods of working are traditional. In one part of the workshop the men are carving the soft pine frames; then come the successive coats of "gesso," followed by the delicate manipulation of the hardened coats with steel tools. The carver can not only carve and gild, but he can draw, and appreciate form and light and shade. He is something of a sculptor, in any case he is an artist craftsman. He was all this in England in the old days, but has been turned away from the true exercise of his business by modern trade pressure and the use of cheap substitutes, so that his work has lost those precious qualities that once gave it artistic dignity. So it is with the best class of workers in wood and iron; they still exist, but they are few in number and difficult of access at first hand.

In the matter of woven stuffs there is, happily, no such difficulty. Never was there a time when such a wealth of good and beautiful material was at the service of the decorator. This branch of trade has in the last twenty years taken an immense stride, and we may well be proud of the products of English looms, and grateful to their designers and producers. The reproduction of the fine old Italian silk damasks in the original designs, and in others of home production of nearly allied character, has enabled us to hang our walls with noble decoration without the trouble and humiliation of having to go abroad for our material. How much of the gain in beautiful material of English manufacture is due to the influence of William Morris it is impossible to guess, but his example of the production of perfectly honest work, combined with design of highest excellence, must have had some effect on the branches of trade in which he is a worker. The enormous influence he has had in the education of public taste, or at least in arousing the educated public to a state of desiring better things, and of appreciating those better things when put before it, cannot for a moment be doubted.

Those who have practical experience in house decoration know how much easier it is to go wrong by doing too much than by doing too little. It is the commonest fault of the trade decorator. He will use three tints where one is better, and if left to himself is sure to overdo everything. I lately saw a house that had just left the builder's hands. The details were all simple and straightforward; all spaces of woodwork, cornices and ceilings had been left in plain white, the effect was quite satisfactory; the whole impression was that of a well designed house, with plenty of space and sufficient enrichment. I saw it again after it had been "decorated;" it was ugly, unrestful, labored; there was not a room in which one could feel at home. Much money had been spent to produce an evil result.

I saw a set of rooms in the Holborn district, in a house built in the last century; not large but of good proportion, the walls paneled in wood. They had been left in bad condition by the late tenant, grimy and battered; the walls had been badly painted in tints. The new tenant had them cleaned and repaired and painted white throughout. The floors, in bad condition, were painted a dark, quiet color and laid with a few well chosen rugs. In the principal room some pieces of good hardwood furniture; simple curtains and suitable chairs completed a room which is now full of charm, and sympathetic alike for work or rest.

I know a room left from the hands of a builder whose traditions are good, whose honesty is the one thing honesty can mean. The cornice, the panelings, the skirtings, the simple stone chimneypiece; every detail carefully thought out, nowhere a weakness or a bungle. All simple, charming, quiet; everything done to make the work good, no effort visible. A room where your favorite chair can stand in the best relation to fire and light, your writing table, your lamp, all that is needful for use and comfort. The room is partly a library, the books, many beautiful and rare, make part of the decoration. It is a joy to enter this room, and a happiness to remain. It is the simplest thing possible; the work of an architect of high repute and of an honest builder, decorated only by its own unaffected and good detail in stone and wood. In this room no other kind of decoration is possible.

There can be no doubt that the noblest form of house decoration is that in which the ornamented parts are planned from the beginning and carried out as the structure proceeds; the enrichment growing out of the construction, not stuck on as an after thought. In such a house one has the enjoyable feeling of repose and contentment that comes of good proportion and proper balance of parts; no matter what its size or cost, a house so carried out will, from the simplicity of its requirements, be easy to furnish and delightful to live in. A noble example of a London house so planned and built and furnished is Dorchester House; the design of a true artist for a client who was also in the best sense a true artist. Here we have splendor of size and material, consummate workmanship, masterpieces of fine art, no jarring note anywhere, everything right and fitting; the best possible and most beautiful. But a house may be built with the same intention and yet not be a palace, nor of great cost, as we see by many houses in Bloomsbury and Soho; some of them, as in Gerard Street and Dean Street, quite small, and yet with rooms full of dignity, because of their good proportion, good detail, and evidence of careful design throughout. Frequent in these houses is the well-looking hall pavement of black and white squares of stone and slate. Think of it in comparison with the deal boards and oilcloth prevailing in the middle class house, a vicious combination purely British. In France the same class of house would have the floor either of red tiles or of oak or walnut, in all cases neatly and frequently wax polished.

It is just with the ordinary dwelling house, large or small, that most persons are concerned. In going through some of the decorative requirements of such a house, it will be difficult to avoid repetitions and truisms. The subject is, in a way, so familiar to all, that there remains little to be said that is new. The only thing that can be done is to lay stress on what is true and best worth doing, even though it may be perfectly well known already. It may be well to go briefly through the principal rooms of a country house of medium size, such a house as would be built for from £6,000 to £9,000.

The entrance or vestibule is probably little more than a wide passage leading to the hall. If it can be paneled in hardwood and have a stone or marble floor in plain squares of two colors, it will need no other decoration. If its size allows, here is the place for a table for hats and overcoats, and a chest for extra winter and carriage wraps.

A roomy hall for use as a sitting room is deservedly growing in favor, and is a part of nearly all houses now being built. It is both convenient and comfortable as a general informal meeting place. People who come in from shooting and hunting hesitate to come into the drawing room with mud on their boots and clothes, but they come willingly at tea time into the less formal hall. For the flooring there is ample choice of material; marble, stone, oak or good red Staffordshire tiles. In France the flooring tiles are much improved in appearance by wax polishing, a plan that has the additional advantage of rendering the surface less pervious to dirt.

Well designed oak paneling is always a good wall covering, carried up as high as the height of the room demands. In this case the doors and architraves and the chimneypiece must come within the same design. Old tapestry is always a beautiful wall decoration, rich and quiet in effect. Modern handmade tapestries are to be had, both of French and English make, but their prices are beyond the means of any but the most wealthy. There are useful woven woolen fabrics for wall hangings, not intended as deceptive imitations of hand-made tapestries, but of good effect and moderate cost, that have their place in honest decoration. The chairs in the hall are most suitably covered in leather, though chintz is not inadmissible. Ordinary cowhide, as used by saddlers, is one of the best leathers for chairs; it will last a lifetime, and mellows with use to a beautiful brown color. A large screen is in place in this room, shutting off the door to the entrance. The stairs rise from the hall and add to the interest of the room. The high hall with galleries giving access to the bedrooms is not comfortable; it is difficult to warm, and the pleasant sense of privacy is lost.

Respecting the dining room there are some good old conventions that are worth retaining. That the aspect should be east, or east a little south; the sun is welcome at breakfast time. That its color should be warm, and preferably red. When the table is lighted for dinner, nothing is more in harmony with the cheerful hospitality of the dinner hour than a soberly rich red wall; moreover, when the morning sun has left the room, which then receives the rather cold eastern light, a red color is acceptable and comforting at luncheon time.

The library, as to its main wall spaces, may be trusted to take care of itself; bound books are in themselves good decoration. The bookcases should have simple lines and not much ornament. The flaps on the under sides of the shelves should be of the same wood or of some quiet colored leather, a golden brown for preference. If there are other wall spaces, they should be of subdued coloring. Fine old maps hung on these spaces are almost better than pictures. One large table, solid and long, may carry atlases and any large books wanted for frequent reference, and there should be a roomy writing table, with solid and simple appurtenances, and plenty of elbow room for books of reference or any of the needs of the student. A digression on writing tables may be excused, always in the interest of simplicity and fitness; it will serve to illustrate a principle that should be observed throughout a house in all matters of furniture and ornamentation. The chair should have the right relation to the height of the table. Neither chair nor table should have casters; there should be no fear that the writer, making a sharp movement in a moment of literary elation, should be suddenly parted from his work by the retreat of either chair or table. A plain pad, the whole size of the sheet of blotting paper, is better to write on than any blotting book. Who does not know the discomfort of the cramped blotting book, whose metal mounts and bosses come down with a cruel blow on the polished table when it is opened for use; the blotting paper inside so much clogged with ink that it no longer absorbs; the inkstand whose top shuts with so strong a spring that you must stand up to open it? One remembers other inkstands in an endless variety of torturing forms; the lid formed of a heavy bronze bird, so heavy that when turned back it nearly overbalances the whole structure; the penwiper clogged and clotted with ancient deposits of ink; the impossible pens in varieties of uncomfortable holders. Think of the agate penholder with a heavy silver gilt seal at the end, the discomfort of its bad balance, the fear of dropping it, the vain wish for a plain wooden one. In every appurtenance a trivial discomfort because the articles are supposed to be decorative; and yet how easy it is to have it all comfortable and beautiful. A well designed inkstand of silver or porcelain, large, clean blotting pad, clean ink, clean pens, both of quill and steel, a clean penwiper, stationery within reach, and nothing else at close range.

The drawing room has no excuse for not being beautiful as well as perfectly comfortable. Let the walls be hung with a silk damask, if funds permit, preferably of a rich red, green or deep golden color, for these are the best grounds for pictures. As it is here that visitors are received, it ought to give them a cordial welcome of beauty as well as of comfort. The carpet is perhaps the most important item of all. It should be as good as possible, whether of English make (Axminster for preference) or Oriental. Even a room with indifferent furniture, or furnished with a quantity of trivial objects, may gain some dignity by having a good carpet; in such cases it is certainly the most important thing to desire. The floor should be of polished oak or parquet; the paint work in one tint only, the ceiling and cornice in a warm white; the frieze only, or the ground of it, if enriched, painted in a very pale tint of the prevailing wall color. It is important to place and group the furniture so that there is plenty of room for circulation. What does one so often see in the newly decorated drawing room? Confusion, incongruity, intended ornament wrongly applied. Coloring unsuited to aspect, furniture of various styles jumbled together; too many things everywhere, tables covered with useless articles of no real beauty; no freedom of circulation. Paintwork in many tints, ceiling and cornice of mean design elaborately picked out and gilt, labor and effort wasted, and nothing gained but fussiness and worry.

The bedrooms require the most careful considera-

tion. It is well to remember that in times of illness your bedroom is either your prison or your pleasaunce. Cheerfulness and absolute comfort are the requirements here. The room should not be encumbered with much furniture. It is far best whenever possible to have the furniture fitted and fixed. Recesses such as frequently occur right and left of the chimney breast should be fitted as wardrobes. Their simply painted paneled doors add much to the appearance of the room. Pictures are of doubtful advantage in a bedroom. There is just now a happy reaction in favor of the so-called chintz papers of bold flower patterns; they give a delightfully cheerful look to a room, and with them pictures are quite out of place. Papers with cold gray grounds should be avoided. They are always dull and cheerless. It is a good plan and a clean and wholesome one to paint the margins of the floors for about eighteen inches from the walls. Paint is better than stain, it is easier to renew when worn, and can be applied to any old floor where stain would make a bad job; it also offers a variety of coloring that helps in the decoration of a room. With a painted margin less carpet is wanted, the carpet need not be elaborately "planned" to fit recesses and projections, and being of a rectangular shape, it can be changed end for end when one part gets a little worn. The modern brass bedstead is surely an ugly object, with its hard unsympathetic glitter. How much better to have bedsteads of hardwood well designed, or with head and foot paneled and painted. Surely, taking into consideration the greater attention now paid to matters of cleanliness and sanitation, the old dangers that led to the disuse of wooden beds need scarcely be feared.

Having gone through some of the rooms of a house, a few detached remarks may be worth making on various matters connected with the subject. If the house is to be newly built, it is important to put money into what is permanent. The cost of one Brussels carpet, which is worn out in seven or eight years, will in many cases pay for the difference between a deal and an oak floor. The cost of three times repainting represents approximately the difference between a deal and a hardwood door; moreover, in the case of the deal door the house is burdened with the never-ending expense of repainting at certain intervals. The painter may be abolished forever as to the outside of the house by having leaded lights in stone or oak mullions, and outside doors of oak, and it is well to remember that outside painting is a troublesome annoyance as well as an expense.

The question of pictures in many houses is a difficult one. Often the existing pictures are hopelessly impossible to classify and not really decorative anywhere; the subjects perhaps of purely personal interest. In the case of watercolors and prints, if they cannot be used as decoration, they can easily be unframed and put in a drawer or portfolio. Photographs are almost always undecorative, even if of fine works of art, and quite inadmissible as room decorations when the subject is the family group on the hall door steps, or the eleven cricketers, of whom the son of the house is one. However interesting to individuals, they are not decoration. The place for these and the many portrait photographs seen in every drawing room is an easily accessible drawer or really beautiful box of inlay, of silver, of tortoise shell, or any decorative material.

There can be no objection in a hall to trophies of antlers; but they lose all decorative value if the animal's head is stuffed and made to look as much alive as possible. This is right in a natural history museum, but is out of place as decoration. The antlers should be attached to a part of the skull, as we see them in old halls. Trophies of chase and war are always interesting and may be treated happily, as the walls of many old houses testify.

Modern wall papers have nearly kept pace with woven fabrics in excellence of design and coloring, though many a good design gets lost or put aside in consequence of the restless desire for something new. Happily some of the best retail firms retain a collection of fine designs, some of the blocks dating from the last century. Flock papers of good damask patterns in one color, or in two near shades of one color, are a good wall hanging for many rooms, and suit pictures well. The old Chinese wall papers are still occasionally to be had; they are somewhat costly, and require to be hung by an expert, but they are extremely decorative, more so indeed than the really better drawn Japanese hand-painted papers.

The decoration of London houses is complicated by the unceasing war against all-pervading dirt. Every damask-hung wall and every item of furniture covered with a woven fabric must be protected with linen covers when not actually in use. It is best to have varnished woodwork; and in passages, and indeed wherever such treatment is admissible, varnished wall papers. Where there is white painted woodwork the windows had better be pasted up when the house is not in use, as the exclusion of light from closed blinds and shutters will turn the paint yellow, a fact often forgotten.

Dutch tiles, now easily to be had both in plain colors and in a large variety of the old traditional designs, are much to be recommended for use on the walls of basements. It is good to feel that in one part of a London house at least the demon dirt can be banished forever.—National Review.

COMBINED DYNAMO AND TURBINE.

WE illustrate a combined dynamo and turbine which has recently been built by Messrs. J. P. Hall & Co., of the Blackriding Iron Works, Werneth, Oldham. As shown in the general view (Fig. 1), the dynamo and turbine are mounted on the same bedplate. The dynamo is designed to give an output of 50 amperes at 80 volts, when running at 730 revolutions per minute. It has an armature of the Gramme wire-wound type, while the commutator segments are of hard-drawn copper, insulated with mica. The brushes are of carbon, and the machine is so designed that the lead of the brushes may re.nain unchanged at all loads without sparking taking place. The field magnets are of wrought iron, and are shunt-wound. The electrical efficiency is about 86·33 per cent. The turbine, a section through which is shown in Fig. 2, is of the Girard type, and is intended to give six horse power when supplied with 36 cubic feet of water per minute under a head of 120 ft. The guide ports are four in number, and can be closed successively by a revolving sluice, the spindle of which passes out through the turbine casing, and can be turned by a hydraulic cylinder, as well as by the handle shown in Fig. 2.—Engineering.

TAR, PITCH AND TURPENTINE.

THE region covered by the forests which produce the naval stores of the world embraces the eastern part of North and South Carolina, the southern parts of Georgia, Alabama, Mississippi, Louisiana and the northern part of Florida.

The southern pine, as it is familiarly called, is known among botanists as Pinus Australis, and comprises several species. These differ chiefly in the length of time they yield the gum, for which they are valuable—those in North Carolina lasting for ten years, while in Florida six years is the average limit of production. The pines of Sweden, Norway and the south of France supply small quantities of naval stores; but their forests are of a species greatly inferior to ours, since they do not yield as much, nor for so long a time, as those of the Southern States.

Though the gum or resin from which the spirits of turpentine is made was known to the ancients, this volatile fluid is of comparatively recent discovery, and it is only within the last forty years that it has risen to the dignity of an article of commerce. For some years previous to this the spirits of turpentine derived from the European pines was used to a limited extent for medicinal purposes. Its great production and extensive use in this country is due to the introduction and universal application of paints, and the necessity for having some volatile vehicle to mix with the oil.

Resin and spirits of turpentine are both derived from crude turpentine. This is the sap of the tree, and is technically known as virgin dip, yellow dip and scrape. The first is the product of the tree for the first year after it is tapped. When of good quality, it is limpid as honey and of a pale straw color; exposure to the air soon causes it to grow opaque and creamy. From the virgin dip are made the beautiful pale grades of resin. A barrel weighing two hundred and eighty pounds yields seven gallons of spirits and about one hundred and eighty pounds of resin.

This dip is used to a limited extent for making plasters and salves. The product of the tree for the second and several succeeding years is called yellow dip. This yields more resin, but not so much spirits.

"Scrape" is the term applied to the sap which exudes from the tree during the last two or three years of its productiveness. It is a wax-like substance of great whiteness when first taken from the tree, but soon turns yellow by exposure to the air. It is used in small quantities for various purposes, besides distillation, one of which is the making frankincense. Taken in small pills, it is an excellent method for removing obstructions of the liver and kidneys and for promoting activity in the general secretions. By distillation it yields a much smaller quantity of spirits than can be obtained from the products of the previous years, but a larger proportion of resin, and of a grade scarcely inferior to that from the virgin dip.

The mode of gathering these products and their preparation is as follows: A cut is made in the tree as near the roots as possible, which, on the outside, is shaped like a half-moon; it extends several inches into the tree, forming a pocket, and is large enough to hold one or two quarts of sap, according to the size of the tree; sometimes two or three boxes, as they are called, are cut in one tree. A good hand will cut from one hundred to one hundred and fifty in a day, according to their size, and on an acre of trees from five hundred to one thousand such boxes may be made. They are usually cut at so much a box, from a cent to a cent and a half each.

After the boxes are cut they are counted off into tasks, generally of ten thousand each, and a laborer assigned to every task. If it is an early, warm spring by the time each task has been cut and counted, the boxes which are full must be dipped out. For this a flat spoon-shaped instrument and an ordinary bucket are used. The man carries the bucket on his arm by an arrangement like that employed in fastening on the shield of former times; he pushes it up against one corner of the box, inserts his dipper, and by a dextrous flirt throws out the gum. A practiced hand will frequently clear the box at one dip. When the bucket is full it is emptied into a larger one, and from that poured by another hand into barrels which are placed at convenient intervals among the trees.

Just after the first dipping the boxes are usually "cornered." This is done by taking out a triangular chip at each end of the half moon. If the season is good, by the time the laborer has cornered his whole task the boxes will be again full. They are dipped out for the second time and then given two cuts on each side with the "hack." This is an instrument resembling a gouge, and the operation of "hacking" consists in taking out a circular chip along the edge of the place where the "corner" chip was previously cut out. These strokes slope downward to the center of the box, so that the gum will all run in that direction.

A box is usually given about fourteen strokes each year at seven different rounds. These will cover a space from one and a half to two feet in height, and as the

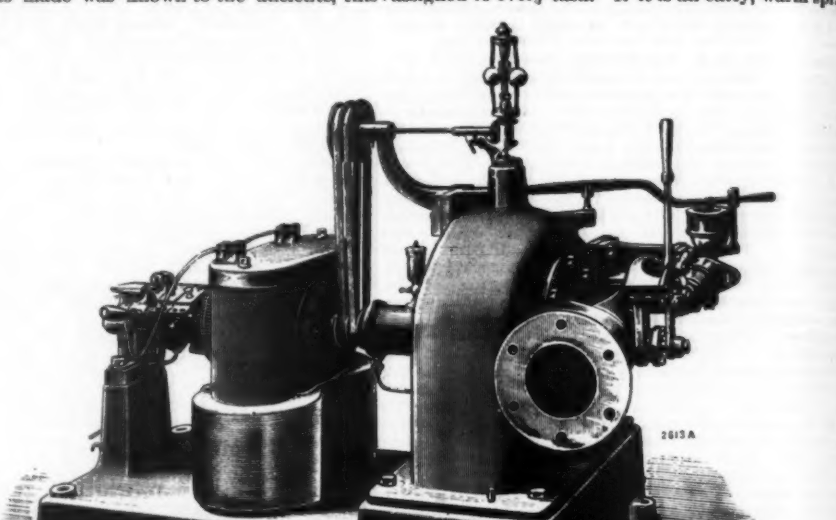
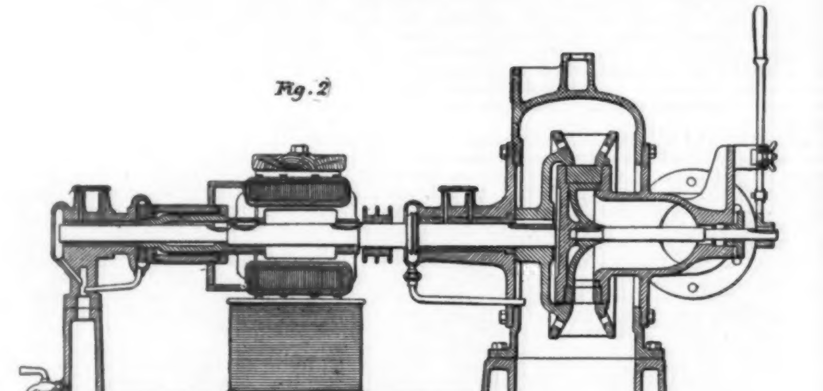


FIG. 1.

Fig. 2



COMBINED DYNAMO AND TURBINE.

trees are seldom worked more than from fifteen to twenty feet in height from the ground, this space will be gone over in about ten years. They are seldom worked much longer than this, since they are of small profit after the first three or four years, but as they have already paid for themselves, what they yield after this period is clear gain.

The tasks are usually assigned to a man called the "hacker," who takes the whole by contract and employs the dippers. In other cases two dippers generally follow one hacker. When the trees are worked to much height, the hack is fastened to a long pole and the man who gathers the "scrape" is obliged to use a ladder. During these later operations a round share is used to scarify the whole face of the box and make the gum ooze out more freely.

The boxing must be done after the sap falls in November and before it commences to rise in the spring. If there are five hundred boxes to the acre, twenty acres will be required to make a task of ten thousand boxes. Two hundred boxes to the acre is all, however, that the average forest will allow.

So far we have spoken only of the production of the gum or crude turpentine. To obtain the spirits and resin the gum must go through a process of distillation. This operation is conducted in large turnip-shaped stills, made of copper and set in brickwork, the fire being applied directly to the bottom of the still.

The stills will hold ten, fifteen, twenty, and sometimes forty barrels of gum. This is "charged" in at the top and the cap fitted on. This cap connects by an arm with the worm, around which cold water is constantly running. When the still is filled and this connection made, the fire is applied. As the process of distillation goes on, the distiller adds, from time to time, a little water to prevent scorching, and tries his "charge" by inserting a rod in a small hole in the top of the still intended for that purpose.

When the process has reached a certain point he draws his fire and allows the still to cool a little; then he takes off the cap and from the liquid mass inside skims off all the chips and bark, of which there is always more or less in the gum. If the cap is taken off too soon, the whole charge will take fire from rapid oxidation. When the hot resin is cooled down, it is drawn off through a pipe at the side of the still near the bottom, and passes through strainers into a wooden tank, from which it is dipped into barrels. Upon the care taken in straining the resin depends much of its value in the market; hence certain brands made by careful men soon become known and command high prices.

The spirits, being condensed in the worm, run out, mingled with considerable water, into a tub, the water, on account of its greater specific gravity, settling at the bottom. From this tub the spirits are siphoned off into well-glued barrels for shipment. Though this whole operation is one of great simplicity apparently, yet, to insure a good article and a high price, much care and strict attention is required in conducting it. A little carelessness may result in a fire which will destroy in a day two or three years' profits. Though the distilling is generally a separate business from gathering the gum, the two are sometimes conducted jointly.

The second year's product, called yellow dip, seldom yields over six gallons of spirits, two hundred and eighty pounds of crude turpentine, and from the scrape only three or four gallons are obtained; but these two products yield proportionately larger quantities of resin.

Many slight improvements have been introduced during the last few years, which cheapen the cost of producing and improve the quality of resin; one of these is the straining of the resin through beds of cotton lint. The quality of all the grades is better within a recent period than ever before. The margin of profit in these pine industries has hitherto been so small that costly experiments have not been tried, and steam has not been successfully used as a heating agent.

Experts are able to judge very nearly the amount of raw gum to be obtained from a certain number of trees, but the same crop of trees can be worked for a number of years, usually from four to six seasons, when the white ridges produced by the hackers extend as high up on the tree trunks as a tall man can reach. But those whose purpose is only to extort as much sap from the pine as possible, not intending to utilize the tree afterward for other purposes, hack the long-suffering trunks as high as an ordinary house, affixing the hacking instruments to long poles, and executing their task at a great height from the ground.

A great deal of turpentine is still made in South Carolina, to which State the "tar heelers" made their way from the pioneer turpentine ground of her twin sister. But Florida, southwestern Georgia and Alabama are now the Mecca of the turpentine distillers, those States possessing vast areas of unbroken forests. When ground formerly planted, but left unused for years, produces a fresh growth of pines, they grow to a great height and are vigorous and strong, but their hearts are not in proportion to their size, and they will not yield much resin or turpentine, though sometimes used for that purpose.

"Old field" pines, as they are termed, are distinguished from the original growth of woods by the shortness of their needles and the number of arms they put out comparatively near the ground; the older pines rising to a great height until they overlook all the surrounding trees, before they branch out at all. Twenty years will produce a fresh growth of pines suitable for all the purposes of the distiller.

MAKING TAR.

Tar is commonly made in the South by simply arranging an earthy covering over fat, light wood, thus confining the heat within in such a manner that the drops of fat (inflammable substance) will exude through this outer covering. Lampblack is made from this crude tar for marking cotton bales, boxes, etc., and the negroes use it for staining into solemn blackness the home-made coffins made of odd pieces of boards, in which they bury their dead. A landowner renting his land to the distillers usually charges about $10 a hundred trees for each season, according to the number of boxes he allows cut in each tree.

It takes about twenty-five barrels of crude gum to make two barrels of turpentine. Men who make turpentine distilling a business, and their only business, move about from one territory to another, owing to the location in which they can secure trees. This transitory existence seems to have a somewat demoralizing effect on their employes, who have earned, whether they deserve it or not, a hard name throughout the country. If any stealing or outlawry goes on when the turpentine people are anywhere about, the misdemeanor is sure to be laid at their door.

A level country without many swamps, nor yet diversified by hills, is considered most promising for turpentine workers. With them, as with the farmers, stock raisers, etc., the seasons mean good or bad fortune, as both the quantity and quality of their productions is affected by the weather. Riding at night through a crop of trees in process of working, the white, slab-like surfaces gleam like so many tombstones through the darkness, but the air is fragrant with the breath of the pines that are yielding up their very life for the benefit of mankind.—Commercial Bulletin.

PHOTOGRAPHING IN COLORS.

PROFESSOR JOLY, of 39 Waterloo Road, Dublin, describes as follows his process of obtaining, by means of a single photographic image of an object, a representation of this object in its natural colors, or in colors seeming such to the eye.

A sensitive film sensitized for the red rays (when all colors are to be reproduced) is exposed beneath a party-colored screen bearing lines ruled in transparent pigments. These lines may lie diagonally or otherwise on the plate. They are ruled in three several tints having such selective light absorptive properties as will secure that. One line will so sift the light passing through it that the sensitive film beneath will be affected in a manner corresponding to the manner in which (according to color measurements and theory) the red sensitive nerves in the human eye are affected by the various wave lengths of the spectrum. A second line will similarly sift the rays falling upon it, so that the plate beneath will be affected in the same manner as the green sensitive nerves are affected by the several wave lengths; the third line will do this in the manner in which the blue violet sensitive nerves are affected. The colored lines are ruled on so as to lie adjacent to one another, and of similar width, a dividing engine or similar machine being employed to shift the plate beneath the pen or pens on the completion of each stroke. The dyes or pigments used must be suited to the sensitiveness of the plate to the several wave lengths. Thus I may use chrysoidine orange for the red selecting line, ethyl green and chrysoidine orange for the green selecting line, water blue for the blue violet selecting line, or any other pigment which I may find suitable. The plate taken for exposure under this screen must be placed in the camera with its sensitive surface bearing in close contact with the ruled surface of the screen. The rays thus fall upon it after passing through the screen. An unlimited number of plates may be successively exposed under the same screen.

Upon the development of the plate in the usual manner an image in the usual silver deposit is obtained which shows no color, but is finally divided into linear areas, every third area registering the image as sifted through the red-selecting dye, every third again the image as sifted through the green-selecting dye, every third again the image as transmitted through the blue-violet-selecting dye. It being understood that the lines upon the primary or taking screen being in the successive order, red, green, blue-violet, red, and so on; no two lines of the same color-selective properties lie adjacent to one another.

From this negative a positive transparency is printed by contact in the usual manner. This contains the same registration of the color-selective properties of the dyes, only that now what was before opaque has become transparent. If now this photograph is viewed through a screen with lines ruled in transparent pigments of the same dimensions as those used in taking the plate, but in three primary colors, red, green, and blue-violet, and so placed against the photograph that a red colored line falls upon a linear strip of the image which had been taken through a red-selected line upon the taking screen, a green line upon a strip of the image previously obtained through a green-selecting line, and so for the blue-violet also, then the image is seen in its original colors. To produce this effect upon the eye and also not to interfere with the form of the image, the lines must be of sufficient fineness to blend—or be unobtrusive—when viewed by the unaided eye. Hence it is desirable that the lines be ruled some 200 to the inch or closer.

In viewing the picture through the party-colored screen it is essential that the lines upon both plates (the photograph and the screen) be in close contact. I may use plates of specially flat or polished plate glass to secure closer contact; I may also rule the primary colors directly upon the photograph. Similarly I may use a sensitive plate for taking the photograph in the first instance which has the requisite selectively absorbing color tints ruled directly upon the sensitive surface and which may wash off in the subsequent operations attending development. I may of course develop the original photograph as a positive and then rule the lines upon its surface.

Instead of a linear "pattern" I may use one consisting of squares, diamonds, or any other similar suitable forms, the colors in this case being stamped or rolled upon the plate from a surface bearing minute raised patches suitably spaced, so that after three such printing operations the entire surface of the plate may be overlaid with patches of the three requisite colors in close juxtaposition. The taking and viewing screens are of course stamped or printed to the same dimensions and form of "pattern," or I may lay in the tints by use of dotting pens, which are vibrated mechanically as the plate is passed beneath them. I may also take and view the photograph through lines having the same tints—that is, tints approximating to the three primary color sensations. Or I may secure an approximation to the original color sensations by the use of more than three tints, as in some methods of composite photography, and these may be the same both in taking and viewing the picture. In cases where I use the same tints for the lines used in taking and viewing the picture I may lay those down upon the solid transparent support of the sensitive film as a substratum, and varnishing the ruled lines with water proof varnish, deposit the sensitized emulsion upon this substratum. Such a plate is exposed in the camera through the transparent tinted support and developed as a positive, when without further treatment it reproduces to the eye the colors of the original object more or less accurately when viewed as a transparency. I may in all cases aid the reproduction of the original colors by the use of uniform color screens inserted in the path of the rays falling on the plate either for part of the time of the exposure or during the whole time. Thus I may aid in the registration of the red rays by inserting a screen cutting off the shorter wave lengths, more or less, for a portion or the whole time of the exposure.

Where the same finely distributed tints are used both in taking and viewing the photographic image, these may not necessarily be deposited according to an accurate "pattern" upon the plate, but promiscuously as in the form of fine flaky dust let fall upon the plate and protected by a waterproof varnish, or contained in a layer of gelatine maintained in a fluid state while the dust was being deposited. The dust may consist of minute particles of glass colored in the requisite tints, or they may be impressed upon the plate as previously described by printing from a surface with a raised pattern. Or such colors may be laid on in colored fluxes and burnt into the glass support. Again, such fluxes mixed with a suitable liquid may be ruled upon the plate in fine lines, as before described, and then burnt into the plate. Or by passing the plate under three successive rollers with suitably spaced raised lines or spaces the three colors may be deposited. In all these cases I may keep the plate at a raised temperature while putting in the color, so as to facilitate the drying of the inks and preserving the adjacent lines from running into each other.

The tints, red, green and blue, carried by the view screen are those of the fundamental color sensations, approximating to the tint of the red lithium band of the spectrum for the red, to the green of the E line region of the spectrum for the green, and to a lapis lazuli blue for the blue. These are ruled upon the screen in such depths as will secure that the finished screen shows little or no color to the unaided eye when looked at by transmitted light, but looking darkened or gray, due to the light absorption of the three tints. I may also depart from these tints somewhat when it may be requisite to do so in order to secure that one and the same screen shall serve both for taking and viewing the picture. Or I may even add to the number of tints in accordance with same methods of composite photography, or use less than three tints when pictures of less variety of tints are required.

I find that the aniline dyes, mixed with thin dilute gum arabic, are suitable for ruling upon the plate—more especially if this is coated with a thin layer of clear gelatine which has been allowed to dry before the colors are ruled upon it. I use ordinary drawing pens with carefully set blades. These are conveniently provided with micrometer screws for adjusting the width of the lines. But generally it is requisite by microscopic examination to make sure that each line has the correct width. It is best to provide separate pens for each color, and have these displaced relatively to each other by such an amount that the lines ruled by the leading pen are dry before the lines made by the second pen are deposited near them, and so also for the third set of lines. This displacement may either be at right angles to the direction of the lines or in the direction of the lines; at the conclusion of each stroke across the plate, the plate or pens are shifted by the action of the screw of the dividing engine through the width of three lines in a direction at right angles to the direction of the lines.

I may mix the dyes with gelatine and rule this upon the plate, which may or may not be coated with a preliminary layer of gelatine; the aniline colors or other coloring matters may be dissolved in warm dilute gelatine and ruled on to the plate while in a fluid condition. In this case I maintain the pen or pens warm by the use of a spiral of platinum wire surrounding the upper part of the pen, so that when this is heated by an electric current the requisite temperature is maintained. Or I may warm the metal frame carrying the pen or pens by the use of gas jets, or other means.

The plate to be ruled may be plain glass or carry a thin film of clear gelatine as a substratum. The plate may also be warmed, but I find it an advantage to let the gelatine cool sufficiently upon contact with the plate as to render it so far set that no running occurs. In this manner I may rule simultaneously the three colors in adjacent lines, only displacing the pens so much in the direction of the line as to allow of the setting of the one colored line before the next line is deposited alongside of it. Or I may arrange the pens in the manner already described.

I may use any convenient solvent for the dyes for making the inks and any convenient substratum upon the plate, or I may dispense with this latter altogether. I may rule the lines upon celluloid or other transparent support.

The lines may be varied in width when it is desired to give prominence to one particular tint in the objects photographed. The width of the lines on both screens must, however, correspond. Thus, if to strengthen the reproduction of the red, for example, the red selecting pigment on the taking screen is ruled somewhat wider than the green and blue selecting pigments, then the lines on the view screen in the fundamental red color must be correspondingly wider than those lines which carry the green and blue tints.

The lines on the view screen may, if necessary (as in the case of large plates), be ruled so much narrower than those on the taking screen as will allow for the shrinkage of the photographic film in the process of development; where this might amount to so much as to cause want of coincidence between the lines or other "pattern" upon the photographic image and upon the view screen. The colors of the view screen may underlie the sensitive film, being primarily deposited upon the glass support; the colors of the taking screen may be carried on the outside surface of the sensitive film, being deposited in exact register with the view colors beneath. The plate is exposed through these last colors, which wash off upon development. Or it may only carry the view colors and be exposed through a

removable "taking" screen. In these cases the plate is developed as a positive when it may be viewed as a photograph in colors, owing to the presence of the visual screen beneath the film.—Photographic Times.

SAND FILTRATION OF WATER, WITH SPECIAL REFERENCE TO RESULTS OBTAINED AT LAWRENCE, MASSACHUSETTS.*

By George W. Fuller, Biologist in Charge of the Lawrence Experiment Station, State Board of Health of Massachusetts.

With the increase in our knowledge of epidemiology and the causation of certain diseases, it has become clearer than ever before that more careful attention must be given to the quality of water supplies. It is true that drinking water is not the source of all deaths from diseases, the germs of which are known at times to be water-borne. Certain weight must be given to infected milk and other foods, to deficient drainage and sewerage, to neglect of laws of personal hygiene, and to other sources. Owing to the general absence of the results of sanitary analyses and of sanitary inspection, it is impossible to state at present how important is the part played in the transmission of diseases by each of these sources. In the case of water, however, it is positively known that its part in the causation of certain diseases is a prominent one; authorities differ only as to the degree of its prominence.

Sanitarians clearly realize that opportunities for supplying large communities with pure drinking water from ground water sources, or from surface waters taken from uninhabited water sheds, are becoming fewer and fewer. They recognize, furthermore, that the time has fully arrived when strenuous efforts must be made, in the interests of the public health, to afford practicable and reliable means for freeing infected water supplies from disease-producing germs.

Bacteriology teaches us that water may be sterilized in three ways; by means of chemicals, by means of heat and by means of filtration. While chemicals have been of much aid in surgery by bringing about antisepsis and asepsis, it is very improbable that people would allow their drinking water to be drugged with chemicals, even with the view of removing dangerous bacteria — indeed, such a method might prove very dangerous in many cases. Heat is a much safer means of sterilization, and its application in the household has doubtless done much good. But on the ground of practicability and economy, as well as of reliability, in the light of our present knowledge, each of these methods of sterilization for the removal of disease-producing germs from water supplies drops into relative insignificance when compared with filtration.

At the annual meeting of this association at Chicago, last year, I had the honor of presenting to you some of the results of the investigation upon water purification made by the State Board of Health of Massachusetts. It was then shown that all disease-producing bacteria in the Merrimac River at Lawrence may be removed by slow intermittent filtration through fine sand and loam. But this is not all that the filter accomplished in the removal of bacteria. Out of 103 analyses, 58 indicated that the filtered water was absolutely sterile. Furthermore, the few bacteria which were found in the effluent from time to time belonged to the most hardy species of water bacteria, many of which existed in the form of spores, and which, let it be understood, are not killed by the ordinary application of heat or of chemicals.

Spring water obtained from favorable sources has repeatedly been found to be absolutely sterile. This is the result of natural filtration. This is Nature's method of purifying water, and the efficiency of natural filtration may be attributed to the retention of the bacteria within the filter under an unfavorable environment. The natural consequence of these unfavorable conditions is the survival of the fittest bacteria. Now the evidence at hand shows that the disease-producing bacteria are among the first to succumb, because farthest removed from their natural habitat. The non-pathogenic bacteria eventually perish, also, but unlike the case with the dangerous species, this does not happen until they have established a home and breeding place within the filter. Under the most favorable conditions, filtration may be conducted so that no bacteria pass through with the filtered water. This can only be done under circumstances where the discharge from the filter is sufficiently removed, by time and distance, from the main seat of bacteria activity.

We know that there are a score or more of germs which may produce specific diseases in mankind. There are many more species which are of the utmost benefit to the human race. They accomplish their work by decomposing and nitrifying processes, and convert objectionable organic matter and disease germs to harmless mineral matter. The benefit to mankind of the saprophitic bacteria cannot be overestimated. In this connection it is instructive to quote the conclusion from Pasteur's admirable investigations: "Whenever and wherever there is decomposition of organic matter, whether it be the case of an herb or an oak, of a worm or a whale, the work is exclusively done by infinitely small organisms. They are the important, almost the only, agents of universal hygiene; they clear away more quickly than the dogs of Constantinople or the wild beasts of the desert the remains of all that has had life; they protect the living from the dead; they do more, if there are still living beings, if, since the hundreds of centuries the world has been inhabited, life continues, it is to them we owe it."

In no place in Nature are the opportunities for this bacterial activity more favorable than in filters. We find that the purification of water, with the removal of disease-producing germs by filtration, is Nature's method. We may go a step farther and state that in the purification of water that method is safest which follows most closely Nature's method, and which is least dependent on human agencies.

Nature's method of filtration means the intermittent application of water to sand or soil in rates equal to the rainfall. The economic adoption of sand filtration, particularly as it has been practiced successfully for many decades in Europe, differs from Nature's method, strictly speaking, in that the rate of filtration is much higher and the surface of the sand or soil is covered with water for long periods of time. The essential, underlying principles, however, are the same, because the results are produced by bacterial activity which permanently exists in all filtering materials.

While the removal of pathogenic bacteria by chemicals, including coagulants, and by heat, will forever be directly dependent on human attention and judgment, I venture to predict that the day will come when the knowledge of filtration among sanitary scientists will be such that filters may be constructed and operated by which water free from objectionable bacteria will be supplied to hundreds of thousands of citizens and require the attention of a mere handful of men.

Even under these circumstances the opportunity for exercising personal attention and judgment can be reduced to very narrow limits. In order to obtain this desirable end it is necessary to study thoroughly the laws of filtration from engineering, bacteriological, chemical and hygienic points of view.

For the past seven years the State Board of Health of Massachusetts has been studying the laws of filtration at the Lawrence Experiment Station. In a certain sense, the Lawrence work may be regarded as investigations upon Nature's ways of working, with a view to their more economical and advantageous application to the problems in actual practice. The results of these investigations have been published from time to time in the annual reports of the board. It is fitting on this occasion that I review some of the more important points upon the filtration of water in the annual report of the board for the year 1893, which is just issuing from the press.

In the operation of a filter, one of the important points is the rate at which water passes through the filtering material. As a result of European experience, the conventional limit has been set at from 2,000,000 to 3,000,000 gallons per acre daily. Recent results obtained at Lawrence show that the Merrimac River water may be filtered through proper materials at the rate of 4,000,000, 6,000,000 and even 8,000,000 gallons per acre daily, with practically no diminution in the bacterial efficiency. Farther investigations are necessary to show whether filters may work at this rate for an indefinite time without a period of absolute rest. The maximum rate of filtration allowable depends upon the quality of the water and the quality and quantity of the sand. The advantage of higher rates of filtration with undiminished hygienic efficiency is apparent, because it means reduced size and cost of the filtering plant.

It is well worth noting that in the operation of water filters a greater hygienic efficiency is obtained from uniform than from fluctuating rates of filtration. The disadvantage of fluctuating rates has been demonstrated in the case of some of the older water filters in Europe. From the Lawrence work it appears that with filtering materials of increasing degrees of coarseness and with higher rates of filtration the advantage of uniform rates becomes more marked.

Concerning the depth of material, it has been found that while very satisfactory results may be obtained, under favorable conditions, from filters one to two feet deep, the deeper five foot filters are safer.

The investigations indicate that, within the limits in sizes of sand grains which would be usually employed in filtration, the finer sands are ordinarily slightly more efficient in removing bacteria than the coarser ones.

It has been stated that an objection to sand filtration of water is that the hygienic efficiency is materially reduced during the period which immediately follows the scraping of the surface to relieve clogging. In the light of recent Lawrence results, this period of somewhat diminished efficiency appears to be largely due to mechanical disturbance of the main body of the filtering material during the process of refilling the filter with water after draining and scraping it. The effect of this mechanical disturbance, caused largely by escaping air, is to create places of lessened resistance to the passage of water through the filter, thereby allowing the water to pass through certain limited areas of the material at very high rates and under abnormal conditions of filtration.

It has been found that there are reliable and practicable means of overcoming this difficulty; one method, for instance, is by slowly filling the filter from below after draining.

In regard to the application of water to filters, there are two methods: first, the continuous method, by which the filters are continuously operated with the surface of the sand constantly covered with water; and second, the intermittent method, by which, from time to time, the water is shut off from the surface for a certain period and the water allowed to drain out of the sand, the pores of which fill with air. The advantage of intermittency is that it provides, within the filtering material, an additional amount of oxygen, with which the bacteria may perform their functions.

So far as the experimental filtration of the Merrimac River water at Lawrence is concerned, there is no marked difference in the average results which may be obtained by the two methods of application of water. The reason of this is that a practically sufficient quantity of free oxygen is held in the water as it flows onto the filters. In 1880 it was shown that a small amount of oxygen (one to three per cent.) in the air of a sewage filter was effective, provided that the air was changed so often that some oxygen was always present at every point. That continuous filters at Lawrence are supplied, under ordinary circumstances, with sufficient oxygen, is shown by the fact that it has never been found absent in the effluents as they flow from the filters through trapped outlets. This is confirmed by the results of long series of analyses of the effluents from both continuous and intermittent filters. Moreover, the analyses of the filtering materials themselves showed that the sand from intermittent filters contained substantially the same amount of organic matter as that from corresponding continuous filters.

To make clearer the interpretation of the investigations upon this point, let me state that the quantity of free dissolved oxygen in a water depends chiefly upon temperature and pressure. As there is practically no increased pressure upon water as it flows onto filters, the amount of free oxygen held in the water varies with the temperature, and generally speaking cannot exceed the point of saturation for the given temperature, even after aeration. The maximum quantity of free oxygen held in water varies from 1·47 parts at 32° Fah. to 0·81 part at 80° Fah., expressed by weight in parts per 100,000. Now it will be seen that the quantity of free oxygen, which is absolutely essential to chemical and bacterial purification of water by sand filtration, cannot exceed a fixed quantity in different waters, under parallel conditions of pressure and temperature, while the amount of organic matter in waters under the same conditions may increase within wide limits. The quantity of free oxygen within the filter, which will suffice for the complete purification of the water, must be in proportions corresponding to the organic matter.

For this reason it is clear that spring waters and other waters which contain relatively small proportions of organic matter can be filtered by the ordinary continuous method with complete success, while the filtration by this method of sewage, which contains a comparatively large quantity of organic matter, is an absolute failure. Intermediate between the two in point of organic matter, a line must be drawn, below which either the continuous or intermittent method of application of water to filters is allowable, but above which the intermittent method may alone be used with safety. Not only the quantity, but also the quality of the organic matter, must be taken into consideration, for it is well known that animal matter is more easily decomposed and mineralized than organic matter of vegetable origin.

With regard to the experience at Lawrence, it may be stated that during midsummer, the period of greatest bacterial activity within the filters, and also the time when the amount of free oxygen in the Merrimac River water is least, intermittent filters give somewhat better results. On the other hand, during midwinter, when the Merrimac River water is saturated with oxygen, the advantage appears to lie somewhat in favor of the continuous filters, because they are more protected from the effects of freezing weather.

In order to obtain the required amount of free oxygen, it is necessary in the case of some waters, and absolutely essential in the case of sewage, to charge the pores of the filter with oxygen from time to time, because the quantity which can be applied in the water is limited by the point of saturation. Therefore, the arbitrary adoption of the continuous or intermittent method of application in the filtration of a certain water is not advisable. It becomes a matter of adjustment of the necessary quantity of free oxygen within the filter to the amount and quality of organic matter in the water under consideration.

We have now considered the way in which sand filtration does its work, and referred to some of the controlling factors in its operation. Let us next turn to the hygienic results obtained by filtration and to their interpretations.

At the Lawrence Experiment Station, during 1893, there were made more than 12,000 bacteriological analyses in repeatedly testing the efficiency of twenty individual filters of different construction and operation. The average results of these analyses indicated that 98·54 per cent. of the number of bacteria in the Merrimac River water were removed by filtration. This average includes all normal results, many of which were obtained from filters and under conditions which would not be recommended for adoption in that capacity. Under reasonably favorable conditions, the removal was from 99 to 99·5 per cent. of the number in the applied water. Of the average percentage (1·54) of bacteria which remained in the filtered water, in actual numbers 140 as compared with 9,100 in the river water, a majority appear to belong to the most hardy forms of water bacteria. Furthermore, it has been learned that 15 to 25 per cent. of these bacteria are present in the form of spores, which, as has been stated above, are not killed by the ordinary application of heat and of chemicals.

In studying the hygienic efficiency, we are not dependent alone on the results from these water species of bacteria. Billions of typhoid fever germs, B. coli communis and B. prodigiosus, a species which is similar in its mode of life in Merrimac River water to B. typhi abdominalis, have been cultivated and applied to the filter. When these germs were put on to the filters, in numbers corresponding to the water bacteria, under high rates of filtration, they passed through the filter into the effluent in very limited numbers. They were present in the filtered water, however, in relatively much smaller numbers than the common water bacteria. Under parallel conditions, the ratio of B. prodigiosus to common water bacteria in the effluents appears to range between 1 to 10 and 1 to 5. The average number of these germs, applied in pure culture to the filters, was 6,000 per cubic centimeter, of which 99·81 per cent. were removed by the filters.

The reason why such large numbers of these specific bacteria were applied to the filters was to test the efficiency of filtration under different conditions, and to obtain numbers sufficiently great to show clearly the laws of filtration. It will be admitted by every one that the tests upon the efficiency of the filters in removing these bacteria were far more severe than would ever occur in practice. Looking at the experiments more carefully, it is seen that these germs were applied to the filters for weeks, in numbers equal to those of the ordinary bacteria in the Merrimac River at Lawrence. At times, in fact, the numbers were a hundredfold greater. In order to appreciate more fully these experimental conditions, let me state that in order to obtain in actual practice corresponding numbers of typhoid-fever germs, it would be necessary to add to the drainage of the Merrimac River, above Lawrence, a population sick with typhoid fever and equal in number to the present inhabitants. This statement assumes, of course, that there would be conditions corresponding to the present with regard to sedimentation, the effect of light, temperature, osmosis, etc. It may be safely stated that the experimental conditions at Lawrence are a hundredfold more severe than would ever occur in the filtration of an ordinary water supply. This shows what a large factor of safety lies behind the bacteriological investigations at the Lawrence Experiment Station, and furthermore may serve

* Read at the Montreal meeting of the American Public Health Association. From the Journal of the Association.

to explain the confidence with which those who are familiar with these investigations believe in hygienic efficiency of the sand filtration of water supplies.

The results from the filtration of water at Lawrence are no longer confined to the experimental stage. A filter to purify the water supply of the city of Lawrence has been for the past year in successful operation. From an engineering point of view, this filter contains many important features which are described in the forthcoming report by its designer, Mr. Hiram F. Mills, chairman of the Committee of the State Board of Health, upon water supply and sewerage.

Briefly, it is 2·5 acres in area and contains sand of an average depth of about 4·5 feet. The depth of sand varies from 3 to 5 feet, but owing to the arrangement of the under drains, all water passes through at least 5 feet of filtering material. The filter is situated by the side of the Merrimac River and separated from it by an embankment. Its surface is 2 feet below low water in the river. The water is allowed to flow on to the filter about 16 hours a day on an average, and during the remainder of the time the sand is drained and the pores filled with air. The filtered water is conducted by under drains to a collecting conduit and thence to the pump well. The pumps determine the rate of filtration, and are speeded so that the water shall pass through the filter at the rate of 2,000,000 gallons per acre in 24 hours. From the pumps the water passes to the open distributing reservoir, which is 25 feet deep at high water and contains 40,000,000 gallons. The water then flows by gravity from the reservoir to the consumers.

From the time when the filter was put in operation, September 20, 1893, until May 1, 1894, daily bacteriological analyses, in addition to numerous chemical analyses, were made of the water before and after its passage through the filter, as it leaves the reservoir and from taps at the city hall Experiment Station, which are distant 1·5 and 2·5 miles respectively from the reservoir; the results were as follows:

	Average number of bacteria per cubic centimeter.	Average per centage removed of number applied.
River	19,900	——
Effluent at filter	264	97·58
Water from reservoir outlet	139	98·73
Water from tap at city hall	90	99·17
Water from tap at Experiment Station	82	99·25

The above averages include all results. Excluding those results obtained under conditions which were abnormal and not likely to occur again, we find that this filter normally reduced the bacteria from 9,000 to 150 per cubic centimeter—a removal of 98·3 per cent. of the number applied. Owing to the fact that some ground water of somewhat unsatisfactory quality with regard to numbers of bacteria was at times mixed with the effluent, it is very improbable that all the bacteria in the water pumped to the reservoir passed through the filter.

During the five years preceding the use of the filter, the average annual death rate from typhoid fever in Lawrence was 1·27 per thousand inhabitants. The population of Lawrence is 50,000, and this average rate is equivalent to 63 actual deaths per year. During the past year there have been 26 deaths from typhoid fever, a reduction of 60 per cent. Furthermore it has been learned that of the 26 who died, 12 were operatives in the mills, each of whom was known to have drunk unfiltered and polluted canal water, which is used in the factories at the sinks for washing. Among the operatives of one of the largest corporations, where canal water is not used, there has not been a single case of typhoid fever during the past year.

The test of the efficiency of the filter during the past year has been a fair one, because at Lowell, the sewage of which enters the Merrimac River, nine miles above the intake of the Lawrence filter, there was during the past winter a severe epidemic of typhoid fever.

In conclusion, we may state that it has been found practicable to protect the consumers of infected water supply by means of sand filtration.

HOW GLASGOW IS KEPT CLEAN.*

IN close affiliation with the sanitary department, and under the superintendence of the same general committee of the common council, is the cleansing department. While, for administrative purposes, it is a distinct service, it seems to me important to make conspicuous the fact that the street sweeping, garbage disposal, street watering and other work of this important public department are a part of the sanitary government. Health considerations come first. It is the business of the superintendent of cleansing not merely to manage his department to the greatest possible economic advantage, but to manage it primarily in such a way as to satisfy a fastidious medical officer of health. Mr. John Young, for a number of years at the head of this department, has made it a model of efficiency. To use Mr. Young's own language, the work of the department "embraces (first) the scavenging of all courts and back yards forming a common access to lands and heritages separately occupied; (second) the scavenging and watering of all the streets and roads within the city; and (third) the collection, removal and disposal of all night soil, general domestic refuse, and detritus."

The propriety of cleansing private courts and passageways at public expense is better considered in the practical than in the theoretical aspects. Glasgow has a population of which more than ninety per cent. live in closely built tenement structures, and of which seventy per cent. live in houses of one or two rooms. Health demands that the common courts and stairs be kept clean. Experience shows that, if done properly, the owners would pay their private employes more than the small tax—1 penny in the pound sterling of rental value—which is collected of them as a special rating for this purpose. There are eleven thousand of these courts, etc., to be kept clean, some of which have to be cleansed two or even three times in a day, and all at least once a day. For this work the main cleansing districts are subdivided into sections, which are laid off into about two hundred beats, each of which is cleansed by one man under the supervision of a section foreman.

* From Dr. Shaw's Municipal Government in Great Britain.

The streets (one hundred and eighty-one miles) are swept nightly, most of the work being done by twenty-three horse machines, which are followed by the department's removal carts. A good feature of this work are the iron boxes or bins, with hinged lids, sunk in the sidewalks next the curbing along the principal streets at intervals of forty yards. Men and boys are kept busy brushing up the day litter and depositing it in the boxes, the contents of which are removed by night with the sweepings.

The summer street sprinkling is also done by the cleansing department, and it is done with great economy, for the simple reason that the amount of the street cleansing work varies inversely to the amount of street sprinkling required; and so the regular force of men and horses employed to keep the streets clean during the rest of the year is sufficient to do that work and the watering besides in the summer months.

The sidewalks of Glasgow are left to be swept by owners and occupants, who are, of course, required to keep them clean. The system as a whole results in well-cleansed thoroughfares.

The third distinct portion of the work of the cleansing department is the collection and disposal of domestic refuse and night soil; and this is more difficult and expensive than the other two portions combined. For this service the city is divided into several main districts, regard being had in this division to the points of outlet. The central or business part of the city is served by daily morning dust carts, each house being provided with a special form of covered bucket which facilitates collection. As regards the great bulk of the population living in tenement houses, it has been found best to collect refuse, including such excrementitious matter as is not carried down the sewers, from improved "ash bins" in the back courts. Each main district has a force of men engaged in emptying these bins and wheeling the contents out to meet the night carts, which ply between the district and the nearest "dispatch station" of the department. It should be explained that each district is subdivided for this work into six sections, one section being cleansed every night, and the entire city being thus served once a week. As the use of the water closet system is becoming more general, the amount of excrementitious matter to be collected by the department decreases. But many large factories, besides the numerous "public conveniences" on the streets, make use of the "pail closet" system, the pails being very frequently exchanged and the removal to the dispatch stations being in covered vans. This system of scavenging is as thorough in execution as it is methodical and complete in its plan.

There are three principal and several minor dispatch stations. The most approved in their appointments are the one known as the "Crawford Street Works," opened in 1884, and that at Kelvinhaugh, which dates from 1891. Stated briefly, it is the policy of the department to send out as manure to the farms just as large a proportion in bulk and weight of the street sweepings and general refuse as can be made a marketable article. At Crawford Street the carts drive across a weighing platform to a great dumping and sorting floor. Street sweepings, after a little raking to remove newspapers and large articles, are shoveled through hatchways, without further treatment, into railway wagons standing on the lowest floor. The contents of the ash bins are passed through great revolving double riddles or separating machines. The larger cinders are sorted out and furnish fuel for the establishment's boilers. The finer ashes and cinders pass down to the floor below into the mixing machines, where they are met by the discharges from the tanks holding excrementa. The newspapers, old baskets, boots, bricks, broken furniture, etc., pass from the riddles to a sorting floor, and thence down flumes to the crematory furnaces, where they burn furiously without the aid of any other fuel, a chimney two hundred and forty feet high making a strong air draught. The expense of a much closer cremation and of the drying and condensation of manure, which is necessary in the large English towns from lack of a market for bulky fertilizers, is avoided in Glasgow. The heavy, cold Scotch soil is improved by a coarse and ashy manure that could not be used in the middle counties of England. The sweepings of the macadamized roads, which are not salable, are used by the city, on its own bog-redeemed farm of Fulwood Moss, for filling, top dressing, etc. The total quantity of material carted by the department for the year ending May 31, 1893, was in excess of three hundred and sixty-one thousand tons, and the amount of manure sold was two hundred and seventy-six thousand tons—the difference being made up of snow, drainage of water from muddy sweepings, materials cremated, and macadam sweepings. This is a remarkable record. The manure is sold in fifteen counties, much of it going sixty or seventy miles. The city owns its railway wagons (seven hundred of them), and has an arrangement with all the roads by which the manure is carried for one halfpenny (one cent) per ton per mile, cars returned free. It would be for the obvious advantage of the city to send out the largest possible quantity even if nothing more than freight charges were received. The net proceeds are, however, from twenty-five to fifty cents a ton.

The operations of this department are a charge upon the general police rate, excepting the cleansing of private courts and tenement stairs, which is paid for by the proprietors benefited by means of a special levy of one penny per pound of rental value. There were employed, on the average, throughout the year 1894, one thousand and fifty-three men—five hundred and thirty-seven in domestic scavenging, two hundred and thirty-two in private street and court cleaning, and two hundred and eighty-four in public street scavenging and sprinkling. The city has invested more than $1,000,000 in works and plant, much of this amount having been lately expended to provide for the enlarged area and population secured by incorporation of suburbs. Noteworthy is the acquisition of the so-called Ryding estate of nearly six hundred acres, which, like "Fulwood Moss," will be conducted as a municipal farm and a place for the advantageous disposition of a great city's refuse. The total ordinary expenditure of the department in 1888, including interest, was $370,000. Sales of manure brought in a revenue of $130,000, and after deducting the cost of the private court scavenging met by special assessment, there remained only $190,000 of general charge to be paid out of the rates for an admirable and complete service of street cleansing and watering, and of domestic scavenging for a population of nearly six hundred thousand—a net cost per capita of only about thirty-five cents. And this economy is the more noteworthy from the fact that the ruling motive of the department is that of the health officer and sanitary engineer rather than that of the contractor. Since 1890 the tendency has been toward an increased relative expenditure. Nevertheless, the cost to the rate payers is trifling in comparison with the magnificent service that the cleansing department renders. I am tempted to go into some details of the method used by Superintendent Young in buying supplies (horse feed, etc.) for his large operations. His department has reduced these matters to so economical and business-like a basis, that it has become purveyor to the fire department, the police department, the sanitary department, the markets department, and the parks and gardens department, all of which to a less extent are horse-keeping branches of the muncipal administration.

PHOSPHATES—THEIR PRODUCTION AND CONSUMPTION.

By FRANCIS WYATT, Ph.D.

VEGETABLES derive their food value from their starch, gluten, sugar, gum, and some organic acids, while the value of animal food is due to albumen, fibrine, fats, and small quantities of divers saline matters. All these constitute what are known as proximate principles, the ultimate composition of which is made up of such simple bodies as carbon, hydrogen, oxygen, nitrogen, calcium, potassium, sodium, iron, phosphorus, and sulphur. The elements of our food are, therefore, taken from the air, the water, and soil, and are so fitted together by the plants as to produce the food of those animals termed graminiverous, which, in their turn, afford to us the vast bulk of our animal sustenance. These mysterious inward processes and these marvelous transmutations of inorganic into organic products, through the medium of plants and animals, form the foundation of the phenomena connected with scientific agriculture, the nutrition of plants, and the increase and prosperity of populations. A practical and beautiful illustration of the contrast existing between the respective attributes of vegetables and animals has been furnished by Dumas and Cahours in the following manner:

VEGETABLES.

Produce { Nitrogenous matter,
Fatty matter,
Gum, sugar, starch.

Consume { Carbonic acid,
Water,
Ammonia.

Absorb oxygen, constitute apparatus of reduction and are stationary.

MAN AND ANIMALS.

Produce { Carbonic acid,
Water,
Ammonia.

Consume { Nitrogenous matter,
Fatty matters,
Gum, sugar, starch.

Absorb oxygen, constitute apparatus of oxidation and are locomotive.

A progressive and eventually complete exhaustion of the soil is thus indicated, and we are naturally brought to realize the necessity for its reconstitution by the aid of chemistry, for the reason that while man and animals produce those very elements which are so necessary to the renewed existence of the plants, they both are locomotive and do not, in practice, give back to the earth what they have borrowed from its stores.

Some rough idea of the actual quantity of mineral matter annually withdrawn from the soil by our food plants may be arrived at if we take a given weight of any cereal—say, for instance, wheat—and burn it until it is reduced to a perfectly white ash. If we next weigh this ash very carefully we shall ascertain that its weight will represent about 2¼ per cent. of the material burned. In the same manner, if we burn a weighed sample of the straw of the grain, or, let us say, of hay or of clover, we shall find that the residual ash will represent about 6½ per cent. of the original substance. A chemical analysis of the two kinds of ash, wheat and straw, will show that the first contains about 40 per cent and the second about 8 per cent. of phosphoric acid, and with these figures as a basis, some interesting calculations may be made with approximate accuracy.

The total acreage under cultivation for cereals and grasses in the United States is estimated at 200,000,000 acres, and the total weight of the crops produced from it at 225,000,000 tons.

If the amount of mineral matter contained in this product be estimated at an average of, say, 4 per cent. on the gross—which, we think, would be fair—it gives a total of 9,200,000 tons. If the percentage of phosphoric acid in the ash of the grain and in that of the straws and grasses be taken for the purposes of our inquiry at the low average of, say, 20 per cent., the amount of this valuable material yearly abstracted from the soils by our food crops alone attains the gigantic total of at least 1,840,000 tons, or, say, 19 pounds per acre.

These are large figures, and it would be probably unfair to assume that the whole quantity is altogether lost to the soil. Certain allowances must necessarily be made for farm refuse and for stable manure, but even when these are reckoned with, it will probably be safe to place the actual loss of phosphoric acid at one million tons.

If the average depth of our arable soils in their virgin state be taken at only 9 inches, and if we assume them to have contained, say, 0·10 per cent. of phosphoric acid, their original total was, say, 3,000 pounds per acre; in other words, a sufficient quantity to last for 150 years on the present basis of production.

We must, however, remember that immense bodies

of our soil have long been under cultivation; that the science of agriculture is comparatively new; and that it is only within the past fifty years that any considerable attention has been bestowed upon the problem entailed by possible exhaustion. Very serious inroads have therefore already been made upon our reserves of this necessary plant food, and it is recognized that a large, if not the major portion of our older cultivated lands are already showing premonitory symptoms of impoverishment.

Of recent times the attention of many intelligent farmers has been very forcibly directed toward this important circumstance; they have been taught to realize that if production is to go on, the vital elements must be restored to the soil, and they are now using a number of substances known to contain phosphoric acid, for the purpose of making good the losses entailed by their business operations. The following are a few of the principal substances of this kind, the figures placed opposite to them being offered as broadly approximative and without claims to absolute accuracy:

Name of Substance.	Average contents in phosphoric acid. Per cent.	Probable quantity used. Tons.
Guanos	25	50,000
Fish scrap	2	75,000
Tankage	9	150,000
Bones	24	
Bone black	32	250,000
Bone meal	30	
Superphosphate of lime	12	700,000
Refuse of various kinds from tanneries, glue factories, oil works, etc.	3	300,000

It would appear from these data that the total quantity of phosphoric acid purchased in these various forms does not amount to more than one-fourth of the quantity we have reckoned as taken out of our soil, and either consumed in our cities or exported to feed the peoples of foreign countries every year. It follows that, without counting the considerable additional acreage yearly coming into the category of exhausted lands, there is an actual and active necessity for the use of at least four times our present consumption of phosphatic fertilizers.

In past and prehistoric ages vast quantities of phosphoric acid have been produced and redistributed over the globe's surface, and these have been stored up for us by nature in the form of phosphates in all sorts of places, more or less easily accessible. We have discovered these phosphates associated with the rocks of all eras and of various textures in veins, pockets and beds, and are now producing it in this country and in Canada, as well as in England, France, Germany, Belgium, Spain, Portugal, Norway, Russia, and the West Indies.

The character of the phosphates of lime thus far discovered in the United States is that of amorphous and nodular deposits which occur in the Tertiary formation, the strata of which may be broadly said to hug the coast of the Atlantic Ocean and the Gulf of Mexico from New Jersey to Texas, embracing within its area the most extensive marl beds in the world. Quarries or mines of more or less commercial value and importance have been located and worked in Virginia, North Carolina, Alabama, Georgia, and Florida, and there is no reason why phosphates should not be found in large quantities in States where they have only hitherto appeared to be of very low grade. For the present, however, the only sources that are being largely exploited are the vast beds of South Carolina and Florida, and, unless we are misled by appearances, these seem sufficiently extensive, if wisely managed, to meet all our requirements for an indefinite period.—Chem. Tr. Jour.

THE ANALYSIS OF BAUXITE.

MIX and fuse five-tenths of a gramme of very finely powdered bauxite with 8 grammes of powdered bisulphate of potassium. The fusion should be made in a thin-walled platinum crucible of about 400 cubic centimeters capacity; the cover of the crucible should fit well.

During the first fifteen minutes the crucible should be on a platinum wire triangle over a small flame of a Bunsen burner. The burner flame should be protected from draughts by a sheet iron chimney, and the flames at first should just touch the crucible bottom. At intervals of five minutes remove the cover carefully and give the contents of the crucible a rotating motion, holding the crucible firmly in the tongs. At the end of fifteen minutes turn up the flame till the lower quarter of the crucible is red hot; agitate frequently as before.

In ten minutes more turn up the flame full and heat for five minutes, with shaking, cool, add two grammes more of bisulphate of potassium, and gradually bring to a homogeneous fusion, but do not heat long enough to drive off the free sulphuric acid.

Pour out the liquid fusion into a warmed and dry platinum dish; the cake cools and does not adhere to the dish. Place together with the crucible and cover in a 200 cubic centimeter beaker. Add 150 cubic centimeters of water. Heat to 40° C. with frequent stirring, until all soluble matter is dissolved.

Silica.—Filter into two 300 cubic centimeter beakers, and wash the residue. Ignite and weigh as silica. Make correction for silica if the bisulphate of potassium contained any. Also test the silica with hydrofluoric acid, and if any residue is found, fuse it with a little bisulphate of potassium, dissolve in water, and add it to the main solution.

The filtrate from the silica contains the titanic acid, alumina, and oxide of iron.

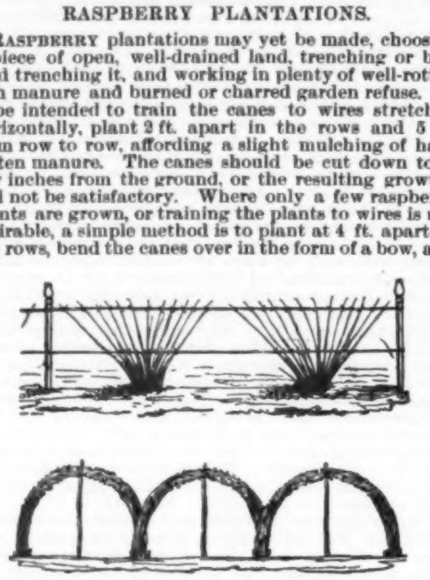
Titanic Acid.—Add dilute nitric acid to slight precipitation, not cleared by stirring. Add dilute (1 to 8) sulphuric acid until this precipitate just redissolves. Add four drops of concentrated sulphuric acid to the solution and dilute to 250 cubic centimeters. Saturate with sulphurous acid gas. Heat slowly to boiling, and boil gently for three-quarters of an hour. Add a little strong sulphurous acid water occasionally to keep the iron in a ferrous state.

Filter through double filters and wash with hot water. Ignite and weigh titanic acid.

The filtrate is boiled until free from sulphurous acid; two cubic centimeters of concentrated hydrochloric acid and two cubic centimeters of concentrated nitric acid are added, and the solution boiled for fifteen minutes to thoroughly oxidize the iron. It is then diluted to 250 cubic centimeters, with hot water and ammonia added in slight excess. Boil gently for five minutes and then warm for five minutes more. Long boiling gives a precipitate which retains potassium salts when washed. Filter and wash thoroughly with hot water. Wash the precipitates off the filters back into the beakers, dissolve in ten cubic centimeters concentrated hydrochloric acid and water, dilute to 250 cubic centimeters with hot water. Reprecipitate with ammonia as before. Filter on the same washed filters. Ignite (finally to highest heat of blast lamp) and weigh as oxide of iron and alumina; fuse with carbonate of soda, boil out with water, filter, and dissolve residue in hydrochloric acid. Titrate iron with bichromate and obtain alumina by difference from total weight of oxides of iron and alumina, calculating the contained aluminum from the oxide.

RASPBERRY PLANTATIONS.

RASPBERRY plantations may yet be made, choosing a piece of open, well-drained land, trenching or bastard trenching it, and working in plenty of well-rotted rich manure and burned or charred garden refuse. If it be intended to train the canes to wires stretched horizontally, plant 2 ft. apart in the rows and 5 ft. from row to row, affording a slight mulching of half-rotten manure. The canes should be cut down to a few inches from the ground, or the resulting growths will not be satisfactory. Where only a few raspberry plants are grown, or training the plants to wires is not desirable, a simple method is to plant at 4 ft. apart in the rows, bend the canes over in the form of a bow, and



RASPBERRY TRAINING.

tie to each other, forming a series of low arches, a stake being put in the middle to steady it.—The Gardeners' Chronicle.

HOW TO EXTIRPATE NUT GRASS, OR COCO.

A FOUR-PAGE circular (illustrated) on nut grass, its description and remedies, has just been issued from the Division of Botany of the United States Department of Agriculture. In accordance with the instructions therein contained the plan of campaign to extirpate nut grass is simply to prevent it maturing seed above ground. Nearly everybody thinks that the nuisance reproduces itself from the nut alone, whereas it propagates a thousand times more from the seed. Hence, to effectually and quickly destroy nut grass on any land infested with it, the soil should be frequently stirred during the growing period of summer, so as to stimulate each tuber and seed to sprout. The best season for fighting it is between midsummer and frost time. Although myriads of the sprigs will show themselves above ground in a day or two after each working of the soil, even in the spring months, yet the seed stems will not shoot up till late in the season, and the secret of success is to cut down every tall stem while in the flowering stage at the latest, and the earlier the better. The old method of destroying coco, or nut grass, by cutting it off beneath the ground every time a sprig appears above the surface is a useless expenditure of labor. It is requisite only to plow or chop down the grass at the regular intervals of working Indian corn, collards, or any other crop. By the above method two years are ample time in which to rid any ground of coco. In fact, one season is sufficient to subdue it, except that in subsequent years a few scattering sprigs will show themselves, which can easily be prevented from going to seed by close attention. One cause which has enabled coco so long and so defiantly to hold its sway in the South is that there are so few crops which are hoed or plowed in the fall of the year.

In addition to the above methods of destroying nut grass by cultivation and cutting, another which has received too little attention may be profitably applied. Choke it out with a vigorous growing crop. After the summer cultivated crop is harvested, plow and prepare the land thoroughly; then seed it heavily to some winter crop adapted to the soil. Crimson clover is the best for this purpose in most localities, and is at the same time a very profitable crop for improving light soils and for winter grazing. Winter vetch may be used to advantage in some places, and cropping with rye or fescue grass for winter grazing, to be turned under for green fertilizer in the spring, is far preferable to leaving the land bare. The winter crop in any case should be plowed under in the spring and followed by a well cultivated summer crop. The increased fertility of the soil resulting from this treatment will enable the farmer much more easily to kill out any remnant of the nut grass or other weeds.

Extreme care should be exercised that only pure seed be sown, for by the thoughtless use of impure seed the farmer is fostering the evil which at other times he is trying by costly labor to prevent.—Kansas Farmer.

EVERGREENS IN WINTER.

AT this season of the year, with the ground covered with snow, the one who loves his garden will find in his evergreens much to please and interest him. In the summer season the flowers and foliage of deciduous trees and shrubs are so attractive that we are apt to pass by our evergreens, as they change but little then. But when late fall comes, and deciduous trees lose their leaves, then it is that evergreens begin to change the color of their foliage, many of them, and in the case of those that make no change, we are more impressed with their beauty then than at any other time. Passing a bed of evergreens the other day, I could not but stop to admire its beauty. It was filled with retinosporas, arborvitæs, cedars and yews, chiefly, and a beautiful display they made. There were two golden retinosporas, Plumosa aurea and Pisifera aurea. The first named is the closer growing of the two. Pisifera aurea is of more open growth, and its golden color is deeper than that of Plumosa aurea. I like it much better of the two, and, as it is not as common as the other, and not possessed by so many, I would advise every one to get it. Besides these in the group spoken of there were these representatives of the same genus: squarrosa, with steel colored foliage; plumosa, dark green; leptoclada, iron color; sieboldi, purple; and obtusa, green.

One of the most striking evergreens was the deodar cedar, Cedrus deodara. Besides that, it is beautifully shaped naturally; its foliage is almost of the color of silver, and, set off as this one was by the various colors of the others, it appeared the choicest of the lot. In very severe winters this gets slightly hurt here; generally only its foliage suffers. But it is thankful for protection while young. The Cedar of Lebanon, on the other hand, is perfectly hardy, but its dark green foliage does not attract as does the silver of the other. Among arborvitæs, in the Thuja section, the Queen Victoria, silver tipped, and Meehani and George Peabody, golden, are still the best. In the Biota section, which is the one that bears the ball-like seed vessels, Rollison's golden still leads, and it is unique in its way. Of a golden green color in summer, when frosty nights come it fades, or changes to a purplish flame color, on the south side especially, the amount of sunshine it gets determining the depth of coloring. The common one, orientalis, as well as its variety aurea, also change, but not so charmingly as the others. I would wish to call attention to the merits of other small growing evergreens. There is the Japanese Cephalotaxus fortuni, which spreads like the English yew, and which, like it, has rich green leaves both winter and summer, and what a contrast to almost all other evergreens is the Irish yew! They may be seen eight feet high, and but two feet in diameter at base, and always of the darkest green. There are numerous yews, from Japan and elsewhere, but none that please me as the first named do. A closely allied genus, Podocarpus japonica, has much of the character of the Irish yew, as well as rich green leaves. Our planters place yews wherever it suits them to have them, but they look the best when sheltered from the sunlight in winter.

Two evergreens of the loveliest green in winter are Cupressus lawsoniana (Lawson's cypress) and Thujopsis borealis, the Nootka Sound cypress. It seems to make no difference what kind of weather comes, the vivid green is there all the time. Excelling the typical form even, in the intenseness of its green, is Cupressus lawsoniania stricta viridis. And while mentioning varieties of this evergreen, I will not pass by the lutescens, a golden form, which, if it has any fault, is rather too golden, not retaining enough green to set off the yellow to the best advantage. The green, golden and silver leaved box are well worthy of consideration. Making innumerable roots, they thrive near buildings where other evergreens would die. For all this, the box likes rich soil and moisture, and only when it gets it will it produce the lustrous foliage which is so pleasing.

Among large growing evergreens, the three light silvery foliaged pines, Pinus cembra, P. strobus and P. excelsa, known respectively as the Swiss, white and Himalayan pines, are always noticed and admired. Cembra is of slow growth, but always of pretty outline and requiring no trimming to make it bushy. It is valuable where a slow growing pine is required. The white and the Himalayan are much alike in many respects. The latter has the longest needles, and they droop very much, and it makes a tree of broader base than the white. Both stand pruning well—as indeed do all pines—becoming then beautiful specimens of dense growth. Our native red pine, Pinus resinosa, is a grand tree. Planted by itself on a lawn, it makes a ponderous looking tree. It grows fast, makes a heavy trunk and has long, soft, drooping needles. Another fast grower, and having deep green foliage, is the Japanese species, densiflora. One of the handsomest of evergreens is the Nordman fir, Abies nordmanniana. It grows into a tree of grand dimensions, and no matter how severe the winter may have been, its close finds the foliage of the same rich green color that it was in the summer. It is one of the best of firs. Others are cilicica, pichta, nobilis and amabilis, all of large growth and green foliage. The concolor from Colorado makes a beautiful tree. The bark of the young wood is mahogany colored. There is a great deal of confusion in the synonomy of the above and some other conifers. All those just named, though long known as piceas, are now classed as abies, the latter changing place with the former. Consequently our old friends, the Norway spruce, white spruce, black spruce, etc., are now piceas. Among these how very beautiful is the Oriental spruce. The foliage is fine, the growth compact, and from its smallest size to when it attains a height of 50 feet, it is always handsome. The Norway spruce varies very much from seed. I have found in seed beds plants which close observers would accept as Orientals, so fine and close was the growth. The Colorado blue spruce is in this

class. The best blue colored ones are hard to obtain. Even eminent collectors send out as best blues kinds which have so little blue that they would pass as Norway spruce. The true blue one is one of the handsomest evergreens in cultivation.

JOSEPH MEEHAN.

Germantown, Pa. —Country Gentleman.

LORD KELVIN'S ADDRESS AT THE ANNIVERSARY MEETING OF THE ROYAL SOCIETY.*

THE anniversary meeting of the Royal Society was held in the apartments of the society at Burlington House, on St. Andrew's Day, November 30.

Lord Kelvin, the president, delivered the anniversary address as follows:

Science has lost severely during the past year. In the list of fellows deceased, which I have read to you, you have heard the names of Tyndall, Milnes Marshall, Van Beneden, Pengelly, Brown-Sequard, Romanes, Alder Wright, Helmholtz, Marignac, Topley, all well known to you as having been in their lives zealous and successful scientific investigators, who have largely contributed to the object for which the Royal Society works, "The Increase of Natural Knowledge." Tyndall, full of fire and enthusiasm in solid experimental work advancing the boundaries of science, contributed largely, by his brilliant lectures and books, to make science popular, as it now is in England and America. By the sad death of Milnes Marshall, on Scawfell, in Cumberland, on the last day of 1893, we lost a young, able, enthusiastic worker in zoology. A few months later, we lost the veteran Pengelly, who did so much for geological science, and gave such delightful and valuable lessons to the larger world of non-scientific geologists, in what he did in his exploration of Kent's Cavern, Torquay. Romanes, full of zeal, fighting to the end with the most difficult problems that have ever occupied the mind of man, and devoting his health and his wealth to promote not merely philosophical speculation, but also the experimental research by which alone philosophy can have a foundation, left us at the early age of forty-six.

A year ago, in my anniversary address, I called your attention to Hertz's experimental demonstration of electric waves, which he found in working out an experimental problem originally proposed by Helmholtz to him when he was engaged in experimental researches in the Physical Institute of Berlin in 1879. An English translation by Jones of Hertz's book describing his work on electric waves, dedicated "with gratitude" to Helmholtz, was published in England and America in December, 1893. On the first day of the new year the disciple died, and within the year the master followed him. Of the whole of Helmholtz's great and splendid work in physiology, physics and mathematics, I doubt whether any one man may be qualified to speak with the power which knowledge and understanding can give; but we can all appreciate to some degree the vast services which he has rendered to biology by the application of his mathematical genius and highly trained capacity for experimental research to physiological investigation.

In his interesting autobiographical sketch he tells us that his early natural inclination was for physics, which he found more attractive than purely geometrical and algebraic studies: but his father could only give him the opportunity of studying physics by his learning medicine to earn a livelihood, and he himself was by no means averse to thus entering on the study of living matter instead of confining himself to the physics of dead matter. I think we may now feel that the world has gained largely by this early necessity for a young man of great genius and power to choose a practical profession.

One early result was his careful examination, while still a student, of the theory of animal heat, and a little later (1847) his great essay, "Ueber die Erhaltung der Kraft," conservation of energy as we now call it, communicated to the Society of Berlin on July 3, 1847, of which he said in 1891, "My aim was merely to give a critical investigation and arrangement of the facts for the benefit of physiologists." As a student he had found that Stahl's theory, ascribing to every living body the possession of the property of "The Perpetual Motion" as an essence of its "vital force," was still held by most physiologists. His essay on the "Conservation of Energy," giving strong reasons for rejecting that theory, though looked upon, at first, by many of the physical and philosophical authorities of the time as a fantastic speculation, was enthusiastically welcomed by younger student philosophers, and must soon have convinced the elder men that, whatever may be the real efficiency of vitality, vast and wonderful as it is, it does not include the performance of work without drawing upon a source of energy. This conclusion had been virtually foreseen before the end of last century by Rumford and Davy, and had been clearly stated and powerfully supported by Joule and Mayer a few years before Helmholtz found it for himself and successfully persuaded others of its truth.

It is interesting for us now to know that, while thus contributing so effectively to the abandonment of the old doctrine that vital "force" can work without drawing on an external source of energy, Helmholtz was even more effectively concerned in the establishment of a new doctrine which has given a vast extension to the province of life previously perhaps undreamed of, but now universally recognized as thoroughly well established, and supremely important in modern physiology and medicine. On recovering from a typhus fever in the autumn of 1841, at the age of twenty, the last year of his undergraduate course in the Army Medical School of the Friederich Wilhelm's Institute, he spent the accumulations of his income, which free treatment at the hospital during his illness had left him, in the purchase of a microscope, an instrument then but little used in medical education.

He began immediately to use it, and made some important observations on the ganglion cells of invertebrates, which, at the suggestion of his master, Johannes Muller, he took as the subject of his inaugural thesis for the doctor's degree, in November, 1842, and which was his first published work.† With the same microscope, he observed vibrios in putrefying liquids, which he described in his second published paper (1843), "On the Nature of Putrefaction and Fermentation." His distinguished comrade, Schwann, in the laboratory of Johannes Muller, had already shown that vegetable cells are present in fermenting solutions of sugar, and that air, which had been highly heated, was incapable of exciting the fermentation which the access of ordinary atmospheric air was known to produce.

Hemholtz found that oxygen, yielded by the decomposition of water in flasks containing small pieces of boiled meat, did not produce putrefaction. Thus the doctrine, held perhaps by all before them, and certainly supported by the great Liebig, that putrefaction and fermentation are purely chemical processes of eremacausis (or slow combustion) produced by oxygen, was thoroughly disproved by the two young investigators. But Helmholtz went farther, and showed almost certainly that the actual presence of a living creature, vibrio, as he called it, bacterium, as we more commonly call it now, is necessary for either fermentation or putrefaction. He proved by experiment that a partition of moist bladder, between the yeast and the fermentable liquid, prevented the entrance of the vibrios which he had observed, and prevented the fermentation.

It had been reasonably suggested that fermentation or putrefaction might be a purely chemical process produced by a quasi-chemical agent or poison secreted by a living organism; but Helmholtz's observation disproved this supposition almost certainly, because any such chemical substance in solution would pass by diffusion through the bladder, and produce its effect without any direct action of the living creatures. Although Helmholtz himself was characteristically philosophical and conscientious in not claiming as absolutely proved what he had only rendered probable, it is certain that this early work of his on putrefaction and fermentation constituted a very long step toward the great generalization of Pasteur, adverse to spontaneous generation, and decisive in attributing to living creatures, born from previous living creatures, not only fermentation and putrefaction, but a vast array of the virulent diseases and blights, which had been most destructive to men, and the lower animals and crops and fruits. It is well that Helmholtz himself lived to see the great benefits conferred on mankind by Pasteur's work; and by the annulment of the deadliness of compound fractures and the abolition of hospital gangrene in virtue of Lister's antiseptic treatment; and by the sanitary defenses against fevers and blights, realized by many other distinguished men as practical applications of the science which his own typhus fever of 1841 helped so much to create.

Close after his work on this subject and on animal heat, followed investigations on the velocity of transmission along the sensory nerves of the disturbance to which sensation is due, the time which the person perceiving the sensation takes to decide what to do in consequence, and the velocity of transmission of his orders along the motor nerves to the muscles which are to carry out his will. Results of the highest scientific interest and of large practical importance were given in two great papers published in 1850.* This was followed a few years later by his "Tonempfindungen," a great work not merely confined to the perception of sound, but including mathematical and experimental investigations on the inanimate external influences concerned in sound, investigation of the anatomical structure of the ear in virtue of which it perceives sound, and applications to the philosophical foundation of the musical art; which holds a unique position in the literature of philosophy, and is certainly a splendid monument to the genius and indomitable working power of its author. Another great work of Helmholtz is his "Physiologische Optik;" who shall say which of the two books is the more important, the more interesting, or the more valuable? Each of them has all these qualities to a wonderfully high degree.

Perhaps the most interesting of his experimental investigations in physiological optics was the measurements, by his ophthalmometer, of the curvatures of the several refracting surfaces constituting the lens system of the eye, from which he ascertained that it is almost altogether by changing the curvature of the front surface of the crystalline lens that the eye is accommodated by its possessor to vision at different distances. His ophthalmoscope, by which for the first time he himself saw and showed to others the retina of the living eye, was a splendid and precious contribution to medicine. By allowing that outlying portion of the brain to be distinctly seen and examined, it has shown the cause of many illnesses which had been regarded as hopelessly obscure; and for diagnosis and guidance of medical treatment, it is now continually used not only by oculists, but by general practitioners.

Constrained as I feel not to overtax your patience, I find it impossible, on the present occasion, to enter upon Helmholtz's researches in mathematics and mathematical physics farther than just to mention his small but exquisite paper on anamolous dispersion, and the grand contribution to hydrodynamics which we have in his "Integrals of the Hydrodynamical Equations which Express Vortex Motion."†

Since our last anniversary, important questions regarding the conduct of the ordinary meetings and the publication of papers, both in the Transactions and Proceedings of the Royal Society, have been engaging the attention of the council, with the assistance of a committee appointed on July 5, 1893. The final report of this committee was submitted to the council on July 5, 1894, when resolutions were adopted accepting some of its recommendations and deferring the consideration of others until after the recess.

At the request of the Royal Geographical Society, a committee was appointed by the council of the Royal Society to consider the advisability of asking the government to undertake an Antarctic expedition. A very important and valuable report on the advantages which such an expedition would bring, both to science and to practical navigation, was presented by this committee to the council on May 24. The council, after much careful consideration, resolved to ask the Lords of the Admiralty to grant an interview on the subject with representatives of the Royal Society. This request was assented to, and an interview was accordingly held between the First Lord of the Admiralty and representatives of the Royal Society; but the proposal of an Antarctic expedition was not favorably received.

The Joule fund committee submitted its report on December 7, 1893, and the council, on its recommendation, adopted the following resolutions:

I. That the regulations for administering the Joule memorial fund be as follows:

(1) That the proceeds be applied in the form of a studentship or grant, to be awarded every year, to assist research, especially among younger men, in those branches of physical science more immediately connected with Joule's work.

(2) That this grant be international in its character, and awarded alternately in Great Britain and abroad, or in such order as the president and council shall from time to time decide.

(3) That it be awarded in Great Britain by the president and council of the Royal Society; and, for award in France, offered to the Academie des Sciences, Paris; and in Germany to the K. Akademie der Wissenschaften, Berlin; or, in any other country, to the leading scientific institution, for award in that country.

(4) That the award in Great Britain be made on the recommendation of a committee from time to time appointed by the president and council of the Royal Society, but not of necessity confined to fellows of the society.

II. That a sum of £100, which is now, or shortly will be, available for the first studentship or grant be awarded in accordance with regulation 4.

The first appointment was accordingly made on June, 21, 1894, when it was resolved:

(1) "That a Joule scholarship of the Royal Society memorial fund be awarded to Mr. J. D. Chorlton, of Owens College, Manchester, for the purpose of enabling him to carry on certain researches on lines laid down by Dr. Joule, more especially with the view of determining the constants of some of the instruments employed by Dr. Joule, which can be placed at his disposal by his representatives."

(2) "That the value of the scholarship be £100, payable quarterly, on the certificate from the authorities of Owens College that the researches are being conducted in a satisfactory manner."

On the occasion of Sir George Buchanan's retirement from the post of chief medical officer to the local government board, it was decided by some of his friends that a testimonial should be presented to him, and a sum amounting to about £340 has been subscribed by medical officers of health, sanitary engineers, and others interested in sanitary science. It was resolved, on the suggestion of Sir George Buchanan himself, that this testimonial should take the form of a medal, to be awarded periodically for work done in connection with sanitary science, and that the Royal Society should be asked to administer the testimonial fund under the following conditions:

(1) The money collected, after paying expenses incurred, to be devoted—

(a) To the foundation of a gold medal of the value as nearly as may be of twenty guineas, with a portrait of Sir George Buchanan on the one side and an appropriate design on the other, to be awarded every three or five years in respect of distinguished services to hygienic science or practice, in the direction either of original research or of professional, administrative, or constructive work.

(b) To the bestowal on the recipient of the medal of the amount (remaining after paying for the medal and discharging the incidental expenses) which has accumulated since the last award.

(2) The medal to be awarded without limit of nationality or sex.

The council of the Royal Society has accepted the trust under these conditions; and it was agreed that the first medal should be given to Lady Buchanan by the testimonialists themselves.

The catalogue department has been specially active in the past session. Mr. Ludwig Mond's generous gift of £2,000, which I announced to the society in my anniversary address last year, has given a new impulse to our operations in that department, and enabled us to increase the staff of assistants. Under the able superintendence of Miss Chambers, volume 10 of the catalogue under authors' names has been completed, and was issued in June of the last year. The society is indebted to several members of the catalogue committee, who have lent their scientific knowledge to aid in the revision of the proofs, and especially to the treasurer, under whose experienced eye every sheet in the catalogue has passed. The preparation of copy for a supplementary volume, which will include papers from a large number of periodicals not included in the existing volumes, is now nearing completion.

The Catalogue Committee have held several meetings and discussed some important questions. The proposed subject index to the existing catalogue has been the chief matter under consideration, and the burning question of the respective merits of an alphabetical and a classified index has been so far settled as to make it possible to commence the work of transcription and translation, nearly 40,000 slips being already finished, so that when the details of the plan agreed upon have been finally settled, as there is good hope they will be in the near future, the preparation of the copy for the printer can be speedily proceeded with. Before, however, any final steps can be taken, it will be necessary that the supplement volume of the catalogue should have issued from the press. The preparations for this volume are in active progress.

A kindred subject, but one of still wider scope, has been discussed by a special committee appointed by the council at their first meeting in the present session. The question, namely, of a scientific subject catalogue, which it is proposed to carry out by means of international co-operation. This committee, with the sanction of the council, have addressed a circular letter to scientific societies and institutions in this country and abroad, offering by way of preliminary suggestions, first, that the catalogue should commence with the next century; secondly, that a central office

* From Nature.

† Hemholtz's "Wissenschaftliche Abhandlungen," vol. ii., p. 663.

* Helmholtz's "Wissenschaftliche Abhandlungen," pp. 763-861.

† Philosophical Magazine, July, 1867, being the translation by Tait of the original German paper, which appeared in Crelle's Journal in 1858, and which has been republished in "Wissenschaftliche Abhandlungen, vol. i., pp. 101-134.

or bureau should be maintained by international contributions; and third, that this office should be supplied with all the information necessary for the construction of the catalogue. The circular invites the views on this subject of scientific bodies and scientific men, without in any way committing the society to farther action. A large number of replies to this circular have been received, many of them carefully prepared and able documents. They will be submitted to the new council of the Royal Society, and will, I am sure, be most valuable in assisting it to judge as to future proceedings.

The principal question which the library committee have had before them during the past session is the accumulation of the stock of Philosophical Transactions from the beginning of the century to the present time. New racks have been erected in the basement, which have partly relieved the pressure on our space, but the committee recognize the necessity of some active measures being taken to increase the sale of this accumulated stock. They are of opinion that the sale might be much facilitated if the memoirs composing the volumes published in the past were made separately available to the public, as is done with those that are published at the present time. On the advice of the committee, the council have empowered the treasurer to treat with one of the leading booksellers with the view of bringing some such arrangement into effect.

The collection of marble busts belonging to the society, which is of such personal and historical interest to all our fellows, has received a most important and valuable accession. The sons of our former president, Mr. William Spottiswoode—Messrs. Hugh and Cyril Spottiswoode—have presented to the society a marble bust of their father, by Woolner, which will find in our apartments a fitting home among the busts of many of our former presidents and distinguished fellows, and will hand down to posterity a striking likeness of one who deserved so well of the society and whose premature decease we all still deplore.

The house and soiree committee have discussed the advisability of increasing the accommodation in the tea room, and have presented a report to the council upon the subject. The council, while not disagreeing with this report, considered it wiser, in the present state of finances, to defer the matter for a time.

A third report of the water research committee has been issued during the present year. It gives the results of further experiments by Prof. Marshall Ward on the "Action of Light on Bacillus Anthracis," and on the "Bacteria of the Thames," and the experiments of Prof. Percy Frankland on the "Behavior of the Typhoid Bacillus and of the Bacillus Coli Communis in Potable Water," the whole filling 242 octavo pages.

Unusually large as was the amount of matter published last year, this year the amount is even larger. In the mathematical and physical section of the Philosophical Transactions, seventeen papers have been published, eighteen in the biological section. The two sections together contain, in all, 1,992 pages of letterpress and 112 plates; to which must be added eight or ten papers now passing through the press, and probably to be issued before the close of the year. Of the Proceedings, ten numbers have been issued, containing 1,026 pages. As a result, the finances of the society are, I regret to say, in not such a satisfactory condition as could be desired. The cost of the publications, which, last year, was far in excess of what it was in previous years, and of what the society could really afford, has, in the year 1894, amounted to nearly £3,260, or about £90 more than it was in 1893. For lithography and engraving alone £1,516 have been paid, as against £977 last year. There is, moreover, an accumulation of printed matter now almost in readiness to be issued, the cost of which has still to be defrayed. To meet this extraordinary expenditure it has been necessary to sell out enough of the society's funded capital to produce £1,000 and rigorous retrenchment will be necessary in order to avoid further loss of provision for continued work in future. While the council feels the importance of all the publications of the society being as completely illustrated and as fully detailed as the subjects discussed may require, it is evident that some check must be placed on the extent of the publications, and the best manner of effecting this end is occupying the careful attention of the council.

The establishment of the Faraday-Davy Research Laboratory, in connection with the Royal Institution, is a splendid benefaction which science has gained during the past year, through the untiring and grand generosity of Mr. Ludwig Mond. The Royal Society interests itself in all work contributing toward the object for which it was founded—the increase of natural knowledge; and while gratefully remembering the assistance so generously given to it in the humble but highly valuable work of cataloguing papers which describe the results of scientific investigations already made, it hails with delight this grand foundation of a practical laboratory, of which the purpose is not the teaching of scientific truths already discovered, but the conquering of fresh provinces from the great region of the unknown in nature.

The greatest scientific event of the past year is, to my mind, undoubtedly the discovery of a new constituent of our atmosphere. If anything could add to the interest which we must all feel in this startling discovery, it is the consideration of the way by which it was found. In his presidential address to Section A of the meeting of the British Association at Southampton in 1882, Lord Rayleigh, after calling attention to Prout's law, according to which the atomic weights of the chemical elements stand in simple relationship to that of hydrogen, said: "Some chemists have reprobated strongly the importation of à priori views into the consideration of the question and maintain that the only numbers worthy of recognition are the immediate results of experiment. Others, more impressed by the argument that the close approximations to simple numbers cannot be merely fortuitous, and more alive to the inevitable imperfections of our measurements, consider that the experimental evidence against the simple numbers is of a very slender character, balanced, if not outweighed, by the à priori argument in favor of simplicity. The subject is eminently one for further experiment; and as it is now engaging the attention of chemists, we may look forward to the settlement of the question by the present generation. The time has, perhaps, come when a redetermination of the densities of the principal gases may be desirable—an undertaking for which I have made some preparations."

The arduous work thus commenced in 1882 has been continued for twelve years* by Rayleigh with unremitting perseverance. After twelve years of it, a first important part of the object, the determination of the atomic weight of oxygen, with all possible accuracy, was attained by the comparison† of Scott's determination of the ratio of the volumes of hydrogen and oxygen in the constitution of water with Rayleigh's determination of the ratio of the densities. The result was 15·82, which is almost 1 per cent. (0·87 per cent.) less than the 16 which it would be according to Prout's law. It is very slightly less (¼ per cent.) than Dittmar and Henderson's value obtained by an investigation‡ for which the Graham medal of the Glasgow Philosophical Society was awarded in 1890. Values not quite so small as these for the atomic weight of oxygen had been previously found by Cooke and Richards (15·869) and by Leduc (15·876). There can be no doubt whatever now that the true value is more than one-half per cent. smaller than according to Prout's law, and that in all probability it agrees exceedingly closely with the results obtained by Rayleigh and Scott, and by Dittmar and Henderson.

The question of Prout's law being thus so far set at rest, Rayleigh, persevering in the main object which he had promised in 1882, "a redetermination of the densities of the principal gases," attacked nitrogen resolutely, and, stimulated by most disturbing and unexpected difficulties in the way of obtaining concordant results for the density of this gas as obtained from different sources, discovered that the gas obtained by taking vapor of water, carbonic acid, and oxygen from common air was denser§ by 1/230 than nitrogen obtained by chemical processes from nitric oxide or from nitrous oxide, or from ammonium nitrite, thereby rendering it probable that atmospheric air is a mixture of nitrogen and a small proportion of some unknown and heavier gas.

Rayleigh and Ramsay, who happily joined in the work at this stage, have since succeeded in isolating the new gas, both by removing nitrogen from common air by Cavendish's old process of passing electric sparks through it and taking away the nitrous compounds thus produced by alkaline liquor and by absorption by metallic magnesium. Thus we have a fresh and most interesting verification of a statement which I took occasion to make in my presidential address to the British Association in 1871:‖ "Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new.

"But nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient, long-continued labor in the minute sifting of numerical results." The investigation of the new gas is now being carried on vigorously, and has already led to the wonderful conclusion that the new gas does not combine with any other chemical substance which has hitherto been presented to it. We all wait with impatience for further results of their work; we wish success to it, and we hope that it will give us, before the next anniversary meeting of the Royal Society, much knowledge of the properties, both physical and chemical, of the hitherto unknown and still anonymous fifth constituent of our atmosphere.

COPLEY MEDAL.

Dr. Edward Frankland, F.R.S.

The Copley medal is awarded to Dr. E. Frankland for his eminent services to theoretical and applied chemistry.

At a time when the classification of organic compounds in homologous series was a comparative novelty, when isomerism was still a profound mystery, and the theory of compound radicles introduced by Liebig was still on its trial, Dr. Frankland made his first attempt (in 1848) to isolate the radicle of common alcohol. Though the attempt was in one sense unsuccessful, inasmuch as the free radicle was never obtained, for reasons which we now more fully understand, the research led to important consequences. The discovery of the organo-metallic compounds and the study of their composition and properties was followed by a recognition of the fact, first, that the capacity for combination possessed by the atoms of the metals was limited (Phil. Trans., 1852), and secondly, that variation of "atomicity," as it was then called, usually occurs by an even number of units (Jour. Chem. Soc., 1866), represented by atoms of hydrogen, chlorine or such compound radicles as methyl, ethyl and the rest. These discoveries form the basis of the modern doctrine of valency, with all the important consequences that follow, including the idea of the orderly linking of atoms, and hence the theories of structure or constitution now current.

The discovery of zinc ethyl placed in the hands of chemists an important new instrument of research, which Dr. Frankland was himself the first to use in his investigations concerning the synthetical production of acids of the lactic and acrylic series. Further important synthetical work, conducted in concert with Mr. Duppa, led to a method of ascending the series of acids homologous with acetic acid.

Dr. Frankland's researches in pure chemistry are almost rivaled in interest by his discoveries in physical chemistry, especially in relation to the influence of pressure on the rate of combustion, on the light emitted during combustion and on the cause of luminosity in hydrocarbon flames.

The important work done by Dr. Frankland in the study of water supply and sewage and illuminating gas has proved of great practical value, and has rendered his name famous in connection with the application of chemistry to technical purposes.

RUMFORD MEDAL.

Prof. Dewar.

During more than twenty years past Prof. Dewar has been engaged in researches of great difficulty, in the first instance at very high and latterly at very low temperatures, his inquiries having extended over an extraordinarily wide field, as will be seen by reference to the Royal Society catalogue of scientific papers.

In conjunction with Prof. Liveing, he has communicated to the Royal Society a large number of papers which have added much to our knowledge of spectroscopic phenomena.

During recent years he has made the liquefaction of gases a subject of deepest study, and in the course of this work has displayed not only marvelous manipulative skill and fertility of resource, but also great personal courage, such researches being attended with considerable danger. One of his chief objects has been so to improve and develop the methods of liquefying the more permanent gases that it shall become possible to deal with large quantities of liquid, and to use such liquids as instruments of research in extending our knowledge of the general behavior of substances at very low temperatures. In this he has already been highly successful. Not only has he succeeded in preparing large quantities of liquid oxygen, but he has been able by the device of vacuum-jacketed vessels to store this liquid under atmospheric pressure during long periods, and thus to use it as a cooling agent.

Very valuable outcome of these labors has been the series of determinations, made by him in conjunction with Dr. Fleming, of the electrical conductivity of metals at exceedingly low temperatures, which have furnished results of a most unexpected character and of extraordinary interest and importance.

Prof. Dewar's experiment showing the great magnetic susceptibility of liquid oxygen is exceedingly important and interesting. His recent observations on phosphorescence and on photography,* and on ozone† at very low temperatures, have given surprising results of a highly instructive and interesting character.

It is difficult to exaggerate the importance of extending these researches, which certainly deserve all possible encouragement and support. The award of the Rumford medal to Prof. Dewar is made in recognition of the services which he has rendered to science by the work which he has already done and the provision he has been successful in making for future work, in the investigation of properties of matter at lowest temperatures.

ROYAL MEDAL.

Prof. J. J. Thomson, F.R.S.

Prof. J. J. Thomson has distinguished himself in both mathematical and experimental fields of work. His first essay on vortex rings showed power of grappling with difficult problems, and added to our knowledge concerning the encounter of rings which came within a moderate distance of one another so as to deflect each other's paths.

His theoretical work in the borderland of chemistry and physics has been very interesting and suggestive. His experimental work has likewise been mainly on the borders of chemistry and physics. He has observed the large conductivity of many gases and vapors, and proved the non-conducting power of several others, founding on the conducting power of iodine vapor important speculations as to its probable chemical constitution.

He has also measured the specific resistance of various electrolytes, under extremely rapid electric oscillations, by an ingenious and valuable method, based on the partial opacity of semi-conducting matter to electro-magnetic waves. Recently he has worked at the discharge of electricity through rarefied gases, getting induced currents in closed circuits in sealed bulbs without electrodes, and, in especial, measuring to a first approximation the absolute velocity of the positive discharge through a long vacuum tube, proving that it was comparable with, though decidedly less than, the velocity of light. He also gave an ingenious theory of the striæ—a theory which he has since endeavored, with some success, to extend to a large number of electrical phenomena, the whole electric conduction and induction being regarded by him from the chemical side as a modified or incipient eletrolysis, or as concerned with electrolytic chains of molecules or "Faraday tubes."

Some of his recent mathematical work on the theory of electric oscillations in spheres and cylinders, and in dumb bell oscillators of the kind used by Hertz, with reference to not only their oscillation frequency but also their damping efficiency, has been of much service to experimental workers in those branches of physics. And, in general, the effective manner in which he attacks any electrical problem presenting itself, as evidenced by his book on "Recent Researches in Electricity and Magnetism," wherein he worthily carries on into a third volume the great treatise begun by Clerk Maxwell, is evidence of consummate ability combined with remarkable energy and power of work.

ROYAL MEDAL.

Prof. Victor Horsley, F.R.S.

A Royal medal is awarded to Prof. Victor Horsley, F.R.S., for his laborious and fruitful researches in physiology and pathology, and particularly for those relating to the functions of the nervous system and of the thyroid gland.

His inquiries relating to the former subject have been pursued for more than ten years, and have been communicated to the Royal Society in a succession of papers, the most important of which have been published in the Philosophical Transactions. The first of the series of researches (Phil. Trans., 1888), which was conducted in co-operation with Prof. Schafer, and concerned the relation of a part of the cerebral cortex (the limbic lobe) to sensation, afforded a new confir-

* "On the Relative Densities of Hydrogen and Oxygen, Preliminary Notice," by Lord Rayleigh, February 2, 1888. "On the Composition of Water," by Lord Rayleigh, February 28, 1889. "On the Relative Densities of Hydrogen and Oxygen, II.," by Lord Rayleigh, February 5, 1892. "On the Densities of the Principal Gases," by Lord Rayleigh, March 23, 1893. "On an Anomaly Encountered in Determinations of the Density of Nitrogen Gas," by Lord Rayleigh, April 19, 1894. All published in the Proceedings of the Royal Society.

† Scott, "On the Composition of Water by Volume;" communicated by Lord Rayleigh, Roy. Soc. Proc., March 23, 1893.

‡ Proceedings of the Philosophical Society of Glasgow, 1890-91.

§ "On an Anomaly Encountered in Determinations of the Density of Nitrogen Gas," Roy. Soc. Proc., April, 1894.

‖ Republished in vol. ii. of "Popular Lectures and Addresses."

* Chem. Soc. Proc., June 28, 1894.

† Phil. Mag., August, 1894, pp. 228, 229.

mation and extension of the doctrine of the localization of cerebral function now generally accepted. While this work was in progress, Prof. Horsley engaged with Dr. Beevor in a long and laborious series of experiments for the purpose of determining with the utmost attainable accuracy the nature of the muscular responses which are evoked by stimulating the convolutions in the quadrumana. The results of these researches were communicated in four papers, of which the first three relate to the "cortical representations" of the movement of the limbs, and of those of the tongue and face (Phil. Trans., 1887-1890); the fourth on the channels (in the internal capsule) by which the cortex exercises its influence on the rest of the nervous system (Phil. Trans., 1890).

These experiments not only served to bring to light a number of new facts, and to elucidate their physiological relations in a very remarkable way, but had a special interest in their bearing on the physiology and pathology of the brain in man. Their importance in this respect is enhanced by the circumstance that in the course of the inquiry the opportunity offered itself of comparing the brain of a monkey with that of the orang (Phil. Trans., 1890), a brain which so closely approaches that of man in its structure that the knowledge acquired by these researches may now be confidently used as a guide in the diagnosis and treatment of cerebral disease. Prof. Horsley has himself shown—and this is not the least of the merits which it is desired to recognize in the bestowal of the Royal medal—in how many instances the knowledge which is acquired by patient and skillful work in the laboratory may be made available for the saving of life or the alleviation of human suffering.

In connection with this leading series of researches two others relating to the physiology of the central nervous system must be referred to. In one of these (Phil. Trans., 1890) Prof. Horsley (in co-operation with Dr. Semon) established the existence, not only of a co-ordinating center in the bulb, but of a cortical area in physiological relation with the respiratory and phonatory movements of the larynx; in the other, in conjunction with Prof. Gotch, he investigated the electrical changes in the spinal cord which are associated with excitation of the cortex and internal capsule, and showed how the observation of these facts can be made available for tracing channels of conduction in the cord.

As regards the thyroid gland, Prof. Horsley's inquiries relating to functions of that organ were, like those relating to the nervous system, begun ten years ago, though the results were not communicated to the Royal Society until three years later. Their purpose was to ascertain the nature of the very marked influence which the thyroid was known to exercise on the nutritive functions of the organism, and to show that this influence is constant and definite. In this field Prof. Horsley has not only the merit of having been one of the earliest workers, but of having at this early period arrived at results which the numerous investigations of subsequent writers have in all essential particulars confirmed.

DAVY MEDAL.

Prof. Peter Theodor Cleve.

The Davy medal is awarded to Peter Theodor Cleve, professor of chemistry in the University of Upsala, for his services to chemical science during the last thirty years, and in particular for his long-continued and valuable researches on the chemistry of the rare earths.

This field of inquiry is pre-eminently Scandinavian. By the manner in which he has cultivated it, Prof. Cleve has shown himself a worthy successor of such forerunners as Gadolin, Berzelius and Mosander, and by sound and patient investigation he has faithfully upheld the traditions inseparably associated with these names. All chemists are agreed that no department of their science demands greater insight or more analytical skill than this particular section. Many of the minerals which furnish the starting point for investigation are extremely rare, and the amounts of the several earths which they contain are frequently very small. Moreover, the substances themselves are most difficult of isolation, and their characters are so nearly allied that the greatest care and judgment are required in order to determine their individuality.

A remarkable example of Prof. Cleve's power in overcoming these difficulties is seen in his masterly inquiry into the affinities and relations of the element scandium, discovered by Nilson. This, one of the rarest of the metals, is found only in gadolinite to the extent of 0·003 per cent., and in yttrotitanite to the extent of about 0·005 per cent. The whole amount of the material, as oxide, at Cleve's disposal was only about one gramme, but with this small quantity he determined the atomic weight of the element and ascertained the characters of its salts with such precision as to leave no doubt of the identity of scandium with the element ekabor, the existence of which was predicted by Mendeleef in the memorable paper in which he first enunciated the law of periodicity. Cleve's research, indeed, constitutes one of the most brilliant proofs of the soundness of the great generalization which science owes to the Russian chemist.

A not less remarkable instance of Cleve's skill as a worker is seen in his research on samarium and its compounds, which he communicated as one of its honorary foreign fellows to the Chemical Society of London. The existence of samarium was inferred independently by Delafontaine and Lecoq de Boisbaudran, but we owe to Cleve the first comprehensive investigation of its characters and chemical relations. From the nature of its compounds, a large number of which were first prepared and quantitatively analyzed by Cleve, and from the value of its atomic weight, which was first definitely established by him, it would appear that samarium most probably fills a gap in the eighth group of Mendeleef's system.

We are further indebted to Cleve for a series of determinations of the atomic weights of the rare substances yttrium, lanthanum and didymium. These are generally accepted as among the best authenticated values for these particular bodies.

No record of Cleve's scientific activity would be complete without some reference to his investigations in the domain of organic chemistry, and more particularly to his studies, extending over twenty years, of naphthalene derivatives. By these researches, made partly independently and partly in conjunction with his pupils, among whom may be named Atterberg, Widman, Forsling and Hellstrom, Cleve has gradually brought order out of confusion and has supplied most valuable experimental evidence of the constitution of naphthalene and of the course of substitution of naphthalene derivatives. Within recent years a score of workers have occupied themselves with the same field of research, and no greater proof of Cleve's accuracy and care as an investigator could be furnished than the manner in which his naphthalene work—confessedly one of the most intricate and complicated sections of the chemistry of aromatic compounds—has stood the ordeal of revision.

DARWIN MEDAL.

Right Hon. T. H. Huxley, F.R.S.

The Darwin medal is awarded to Thomas Henry Huxley.

Of Mr. Huxley's general labors in biological and geological science I need say nothing here. They are known of all men, and the society showed its appreciation of their worth when it awarded to him the Copley medal in 1888. The present medal is a token of the value put by the society on the part of his scientific activity bearing more directly on the biological ideas with which the name of Charles Darwin will always be associated.

All the world now knows in part, no one, perhaps, will ever know in full, how, in the working out of his great idea, Darwin was encouraged, helped and guided by constant communion with three close and faithful friends, Charles Lyell, the younger Joseph Dalton Hooker, and the still younger Thomas Henry Huxley. Each representing more or less different branches of science, each bringing to bear on the problems in hand more or less different mental characters, all three bore share, and were proud to bear share, in aiding the birth of the "Origin of Species." Charles Lyell has long been removed from among our midst. Two years ago it was my pleasing duty to place the Darwin medal in the hands of Joseph Dalton Hooker; that pleasing duty is renewed to-day in now giving it to the last of the three "who kept the bridge."

To the world at large, perhaps, Mr. Huxley's share in moulding the thesis of "Natural Selection" is less well known than is his bold, unwearied exposition and defense of it after it had been made public. And, indeed, a speculative trifler, reveling in problems of the "might have been," would find a congenial theme in the inquiry how soon what we now call "Darwinism" would have met with the acceptance with which it has met, and gained the power which it has gained, had it not been for the brilliant advocacy with which in its early days it was expounded to all classes of men.

That advocacy had one striking mark; while it made or strove to make clear how deep the new view went down and how far it reached, it never shrank from striving to make equally clear the limits beyond which it could not go. In these latter days there is fear lest the view, once new, but now familiar, may, through being stretched farther than it will bear, seem to lose some of its real worth. We may well be glad that the advocates of the "Origin of Species by Natural Selection," who once bore down its foes, is still among us ready, if needs be, to "save it from its friends."

The society next proceeded to elect the officers and council for the ensuing year. We gave the list of those recommended for election in our issue of November 8.

In the evening the fellows and their friends dined together at the Whitehall rooms of the Hotel Metropole.

After the usual toasts the president proposed that of "The Medalists," coupling with it the names of Prof. Cleve and Mr. Huxley. The toast was most cordially drunk. The Times reports the responses as follows:

Prof. Cleve, in responding, quoted the noble words of Davy, "Science, like that nature to which it is bound, is neither limited by time nor by space; it belongs to the world, and is of no country and of no age." In the same sense the Royal Society continued to award its medals to men of science, without regard to their nationality. It was a great and elevating thought that there existed a spot in the world where members of all nations met each other as friends, assisting each other in their work for the advancement of science, and, therefore, for the good of humanity and the prosperity of mankind. It was the first time that the Davy medal had found its way to Sweden, but it was not the first time that other medals of the Royal Society had been voted to professors of the university to which he was attached. The Rumford medal had been given not less than three times to his colleagues, and when he offered to the Royal Society his respectful thanks he was happy to include also those of the University of Upsala.

Mr. Huxley said—I am extremely grateful for the respite which has been afforded me by the distinguished foreigner to whom you have just been listening with so much pleasure, because I am loaded with five distinct and separate parcels of gratitude. That is a substance of which I believe the specific gravity has never yet been accurately determined. I am told that in some parts of the world, and especially in the political world, it is lighter than hydrogen; but in the scientific world, and when the object of it is the approbation of a body like the Royal Society, I am disposed to think that we may rank it rather with platinum, so largely does it affect the destinies of those who are fortunate enough to receive it. In respect of four of these parcels I am simply a representative, and perhaps I ought to content myself with acting purely as a representative of those who I wish had been called upon to express their gratitude for themselves. But perhaps I may venture to add that in some cases I have a little personal word to say for myself, as, for example, in that of the Copley medal, which you have adjudged one of my oldest friends and many years a colleague, so that I have a strong and warm interest in the fact that his great services to the science of chemistry have been recognized. And, again, I think that there is another friend in whom I may claim a personal interest—I mean my friend Prof. Dewar—for the remarkable character of his discoveries allows a person who indulges so little in flights of imagination as myself to think of the time when, instead of the excellent liquid with which we have been supplied here, we may have at these dinners of the Royal Society liquid oxygen bien frappe, and then, gentlemen, with that stimulus there is no saying to what length the eloquence of persons who address you may go. And then, again, in one of the youngest of those whom you have honored with your approbation to-day, and whose work lies within the province in which I am still capable, if not of knowledge at least of appreciation—I mean Prof. Victor Horsley—I may say that it is pleasant to me to see him here like a Ulysses who has escaped from the toils of the Circes of anti-vivisection. But the most difficult task that remains is that which concerns myself. It is forty-three years ago this day since the Royal Society did me the honor to award me a Royal medal, and thereby determined my career. But having long retired into the position of a veteran, I confess I was extremely astonished—I honestly also say that I was extremely pleased—to receive the announcement that you had been good enough to award to me the Darwin medal. But you know the Royal Society, like all things in this world, is subject to criticism. I confess that with the ingrained instincts of an old official that which arose in my mind after the reception of the information that I had been thus distinguished was to start an inquiry which I suppose suggests itself to every old official—How can my government be justified? In reflecting upon what had been my own share in what are now very largely ancient transactions it was perfectly obvious to me that I had no such claims as those of Mr. Wallace. It was also perfectly clear to me that I had no such claims as those of my life-long friend Sir Joseph Hooker, who for twenty-five years placed all his great sources of knowledge, his sagacity, his industry, at the disposition of his friend Darwin. And really, I began to despair of what possible answer could be given to the critics whom the Royal Society, meeting as it does on November 30, has lately been very apt to hear about on December 1. Naturally there occurred to my mind that famous and comfortable line, which I suppose has helped so many people under like circumstances, "They also serve who only stand and wait." I am bound to confess that the standing and waiting to which I refer has been, so far as I am concerned, of a somewhat peculiar character. I can only explain it, if you will permit me to narrate a story which came to me in my old nautical days, and which, I believe, has just as much foundation as a good deal of other information which I derived at the same period from the same source. There was a merchant ship in which a member of the Society of Friends had taken passage. That ship was attacked by a pirate, and the captain thereupon put into the hands of the member of the Society of Friends a pike, and desired him to take part in the subsequent action, to which, as you may imagine, the reply was that he would do nothing of the kind; but he said that he had no objection to stand and wait at the gangway. He did stand and wait with the pike in his hand, and when the pirates mounted and showed themselves coming on board, he thrust his pike (with the sharp end forward) into the persons who were mounting, and he said, "Friend, keep on board thine own ship." It is in that sense that I venture to interpret the principle of standing and waiting to which I have referred. I was convinced as firmly as I have ever been convinced of anything in my life that the "Origin of Species" was a ship laden with a cargo of great value, and which, if she were permitted to pursue her course, would reach a veritable scientific Golconda, and I thought it my duty, however naturally averse I might be to fighting, to bid those who would disturb her beneficent operations to keep on board their own ship. If it has pleased the Royal Society to recognize such poor services as I may have rendered in that capacity I am very glad, because I am as much convinced now as I was thirty-four years ago that the theory propounded by Mr. Darwin—I mean that which he propounded, not that which has been reported to be his by too many ill-instructed, both friends and foes—has never yet been shown to be inconsistent with any positive observations, and if I may use a phrase which I know has been objected to and which I use in a totally different sense from that in which it was first proposed by its first propounder, I do believe that on all grounds of pure science it "holds the field," as the only hypothesis at present before us which has a sound scientific foundation. It is quite possible that you will apply to me the remark that has often been applied to persons in such a position as mine, that we are apt to exaggerate the importance of that to which our lives have been more or less devoted. But I am sincerely of opinion that the views which were propounded by Mr. Darwin thirty-four years ago will be understood hereafter to mark an epoch in the intellectual history of the human race. They will modify the whole system of our thoughts and opinions, and shape our most intimate convictions. I do not know, I do not think anybody knows, whether the particular views which Darwin held will be fortified by the experience of the ages which come after us. But of this thing I am perfectly certain, that the present state of things has resulted from the feeling of the smaller men who have followed him that they are incompetent to bend the bow of Ulysses, and in consequence many of them are preferring to employ the air gun of mere speculation. Those who wish to attain to some clear and definite solution of the problems which Mr. Darwin was the first person to set before us in later times, must base themselves upon the facts which are stated in his great work, and, still more, must pursue their inquiries by the methods of which he was so brilliant an exemplar throughout the whole of his life. You must have his sagacity, his untiring search after the knowledge of fact, his readiness always to give up a preconceived opinion to that which was demonstrably true, before you can hope to carry his doctrines to their ultimate issue; and whether the particular form in which he has put them before us may be such as is finally destined to survive or not is more, I venture to think, than anybody is capable at this present moment of saying. But this one thing is perfectly certain—that it is only by pursuing his methods, by that wonderful single mindedness, devotion to truth, readiness to sacrifice all things for the advance of definite knowledge, that we can hope to come any nearer than we are at present to the truths which he struggled to attain.

THE CONSTRUCTION OF THE VISIBLE UNIVERSE.

By J. E. GORE, F.R.A.S.

AN examination of the evidence we have at present, with reference to the distribution of the visible stars in space, has recently been undertaken by Prof. Kapteyn, of Groningen, and a popular account of the conclusions he has arrived at may prove of interest to the general reader.

It must first be explained that in order to obtain a clear view of the construction of the visible heavens, it would be necessary to know the relative distances of a large number of stars; but as the distances of only a few stars have yet been determined, and the results hitherto obtained are open to much uncertainty, we must have recourse to some other method of estimating these distances. In traveling in a railway carriage, if we fix our attention on the trees, buildings, and other objects we pass on our journey, it will be noticed that all objects apparently move past in the opposite direction to that in which we are traveling, and that the nearer the object is the faster it seems to move with reference to distant objects near the horizon. So it is with the stars. The sun is moving through space, carrying along with it the earth and all the planets, satellites and comets forming the solar system. The effect of this motion is to cause an apparent small motion of the stars in the opposite direction, and the nearer the star is to the earth, the greater will this apparent motion seem to be—as in the case of the railway train.

In addition to this apparent motion, the stars are themselves—like the sun—moving through space, and this real motion is also visible. If this real motion takes place in the opposite direction to that in which the earth is moving, it will add to the apparent motion, and will increase the "proper motion," as it is termed. If, on the other hand, the real motion is in the same direction as the earth's motion, it will tend to diminish the proper motion. In either case, the nearer the star is to the earth, the greater will be its apparent annual displacement on the background of the heavens. The amount of the "proper motion" is, therefore, considered by astronomers to form a reliable criterion of the star's distance from the earth, and the actual measures of distance which have been made show that this assumption is approximately true. Of fourteen stars which have a proper motion of over three seconds of arc per annum, eleven have yielded a measurable parallax, or displacement due to the earth's annual motion round the sun—that is to say that eleven out of fourteen fast moving stars are within a measurable distance of the earth, and therefore near us when compared with the great majority of the stars which are not within measurable distance, or, at least, are beyond the reach of our present methods of measurement.

In the case of small groups of stars, we may assume that the real motions of the individual stars take place indifferently in all directions, and that consequently, taking an average of all the motions of the stars composing the group, the effects due to the real motions will destroy each other, and there will remain as the most reliable criterion the effect due to the sun's motion in space. If, however, we compare the proper motions of groups situated in different parts of the sky, there is a consideration which to a great extent vitiates this conclusion. For, near the point of the heavens toward which the sun and earth are moving, known as the apex of the solar way, and situated about seven degrees south of the bright star Vega, as indicated by recent researches, and near the point from which the sun is moving—known as the ant-apex, about fifteen degrees south of Sirius—there will be no apparent displacement due to the solar motion through space, as this motion takes place in the line of sight with reference to these points of the sky. The observed proper motion at these points will, therefore, be solely due to the real motion of the stars in those regions. In other parts of the heavens, however, the total proper motion will be a combination of the apparent and real motions of the stars, and for stars in different parts of the heavens it will not follow that stars having equal proper motions are necessarily at the same distance from the earth. To make this point clearer, let us assume that there are two stars at absolutely the same distance from our eye, one situated at, or near, the solar apex and the other at a point ninety degrees from the apex, and let us suppose that both are moving through space with exactly the same velocity, and in the same direction, say at right angles to the direction of the solar motion. Then, in the case of the star near the apex, the observed "proper motion" will be solely due to the star's real motion, and in the star ninety degrees distant from the apex the "proper motion" will be solely due to the solar motion.

Now, unless the stellar motion and the solar motion happen to be equal, the observed "proper motions" will not be equal, although both stars are at the same distance from the earth. If both stars are really at rest, the star at the apex will have no proper motion, while the stars ninety degrees distant will have an apparent proper motion due to the sun's motion. To overcome this source of error in estimating the distance of a star from its proper motion, Prof. Kapteyn made use of another measure which is independent of the solar motion. This is the component of the proper motion measured at right angles to a great circle of the sphere passing through a star and the solar apex. The amount of motion in this direction will evidently not be affected by the sun's motion, and from a discussion of the stars contained in the Draper Catalogue of Stellar Spectra, which were observed by Bradley (and of which the proper motions are consequently now known with accuracy), Prof. Kapteyn finds that this motion is "nearly inversely proportional to the distance," that is, the greater the motion, the less the distance of the stars, and the smaller the motion, the greater the distance. Excluding stars with proper motions greater than half a second of arc per annum, Prof. Kapteyn found that for stars at various distances from the Milky Way this component of the "proper motion" forms a good measure of distance.

As the result of his investigations on this interesting question, Prof. Kapteyn arrives at the following conclusions:

Neglecting stars with small or imperceptible proper motions, we have a group of stars which no longer show any condensation in a plane. Stars with very small or no proper motions show a condensation toward the plane of the Milky Way. This applies to stars of the second or solar type as well as to those of the first or Sirian type of spectrum, and evidently indicates that the stars composing the Milky Way lie at a great distance from the earth. The extreme faintness of the majority of the stars composing the Galaxy seems to confirm this conclusion. The condensation of stars of the first type is more marked than those of the second, and this agrees with the fact which has been noticed by Prof. Pickering, that the majority of the brighter stars of the Milky Way show spectra of the first or Sirian type, and, judging from the ease with which the fainter stars of the Galaxy can be photographed, he concludes that most of these fainter stars are bluish, and probably have spectra of the first type, like Sirius and Vega, which are bluish white stars. From an enumeration of the stars included in the Dorpat Catalogue, I find that sixty three per cent. of the stars of the Milky Way, as drawn by Heis, have spectra of the Sirian type.

Prof. Kapteyn finds that this condensation of stars with small proper motions is very perceptible even for the stars visible to the naked eye, and is as well marked in those stars which have spectra of the second type as for all the stars of the ninth magnitude, but for stars of the first type the condensation is still more marked. He considers that this condensation is either partly real or that there is a real thinning out of stars near the pole of the Milky Way. As I have shown elsewhere, M. Celoria's observations with a small telescope, compared with Sir William Herschel's observations with a large telescope, indicate clearly that there is a real thinning out of stars at the poles of the Milky Way.

Prof. Kapteyn concludes that the arrangement of the stars suggested by Struve has no real existence. He attributes the fallacy in Struve's hypothesis to the fact that the mean distance of stars of a given magnitude in the Milky way, and outside it, is not the same.

Prof. Kapteyn finds that the vicinity of the sun is almost exclusively occupied by stars of the second or solar type, a conclusion which reminds us of Dr. Gould's "solar cluster." He finds that the number of Sirian type stars increases gradually with the distance, and that beyond a distance corresponding to a proper motion of about one-fourteenth of a second per annum the Sirian stars largely predominate.

In the group of stars known as the Hyades, however, the components of which have a common proper motion both in amount and direction, stars of the first and second types appear to be mixed, and Prof. Kapteyn assumes that the two types represent different phases of evolution, and that as the brightest stars of the group are chiefly of the solar type, these stars must be the largest of the group. From this fact he concludes that the solar type stars are in a less advanced stage of evolution than those of the Sirian type. This does not agree with the generally accepted view. Thus Prof. Vogel considers the Sirian stars to represent the earlier stage of stellar evolution. Mr. Proctor held the same opinion, and in Prof. Lockyer's hypothesis of increasing and decreasing temperatures in stars of various types he places the Sirian stars at the summit of the curve, and the sun and solar just below them on the descending branch of the curve ("The Meteoritic Theory," pp. 380, 381). These hypotheses are in conformity also with the current opinion that the sun is a cooling body. This discrepancy may perhaps be explained by supposing that the brighter stars of the Hyades form a connected group, and that some at least of the fainter stars do not belong to the group, but are situated at a great distance behind it. In the case of the Pleiades, which form a much more evident cluster, I find from the Draper Catalogue that the great majority of the brighter stars have spectra of the Sirian type. Most of the stars in the Pleiades have a very similar proper motion, both in direction and amount, and there can be no doubt that they form a connected system. The superior brilliancy of the stars composing the Hyades would indicate that they are nearer to the earth than the Pleiades group, and they may possibly form members of the "solar cluster."

Assuming that the distances are inversely proportional to the proper motions, Prof. Kapteyn computes the relative volumes of the spherical shells which contain the stars with different proper motions (from one-tenth of a second to one second of arc, and more). Comparing these volumes with the corresponding number of stars, we arrive at an estimate of the density of star distribution at various distances. The result of this calculation shows that the distribution of stars of the Sirian type approaches uniformity when a large number of the faint stars (the ninth magnitude) are considered. With reference to stars of the second type, however, the larger the proper motion, the greater the number of the stars, or, in other words, the second type or solar stars are crowded together in the sun's vicinity. Evidence in favor of this conclusion is afforded by the fact that of eight stars having the largest measured parallax (and whose spectrum has been determined), I find that seven have spectra of the solar type. The exception is Sirius, which is evidently an exceptional star with reference to its brightness and comparative proximity to our system, no other star of the first magnitude having nearly so large a parallax. Indeed, the average distance of all the first magnitude stars in the heavens has been found to be over forty times the distance of Sirius.

Prof. Kapteyn finds that the center of greatest condensation of the solar type stars lies near a point situated about ten degrees to the west of the great nebula in Andromeda, and that this center nearly coincides with the point which, according to Struve and Herschel, represents the apparent center of the Milky Way considered as a ring. This would indicate that the sun and solar system lie a little to the north of the plane of the Milky Way, and toward a point situated in the northern portion of the constellation of the Centaur. The fact is worth noting that the nearest fixed star to the earth, Alpha Centauri, lies not very far from this point. Possibly there may be other stars in this direction having a measurable parallax. The southern portion of the heavens has not yet been thoroughly explored.

Prof. Kapteyn finds that, for stars of equal brightness, those of the Sirian type are on an average about two and three-quarter times further from the earth than those of the solar type. As light varies inversely as the square of the distance, this would imply that the Sirian stars are intrinsically over seven times brighter than those of the solar type. This conclusion is confirmed by the great brilliancy of Sirius, and other stars of the same type, in proportion to their mass. I have shown elsewhere that Sirius is about forty times brighter than the sun would be if placed at the same distance, although its mass is only twice the mass of the sun, as computed from the orbit of its satellite.

The general conclusions to be derived from the above results seem to be that the sun is a member of a cluster of stars possibly distributed in the form of a ring, and that outside this ring, at a much greater distance from us than the stars of the solar cluster, lies a considerably richer ring-shaped cluster, the light of which, reduced to nebulosity by immensity of distance, produces the Milky Way gleam of our midnight skies.—Knowledge.

THE

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